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WATER WORKS INTAKES OF THE GREAT LAKES REGION[1]

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The subject of water works intakes of the Great Lakes region is necessarily a broad one and cannot be adequately covered within the limits of this paper. It is accordingly proposed to outline briefly the various factors entering into the location and design of such intakes and their connecting conduits, and cite from the information at hand some examples covering the practice that has been followed in the construction of these structures.

In a discussion of intakes for service in this region, it must be remembered that their design and maintenance is affected to a large extent, if not sometimes controlled, by the dangers that are always present in these waters during the season of navigation from passing boats, and during the winter months from ice in one of its several forms. As compared with the depth of these lakes and channels, the boats are of deep draft, their numbers are great, and particularly in the channels their size of necessity causes them to be unwieldy. Throughout this region winter weather is generally severe, and ice of considerable thickness must be expected to form on even the southernmost portion of these waters.

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I. LOCATION OF INTAKE

In locating an intake, the first factor of importance should be to discover the location giving the best water obtainable in the vicinity of the community to be supplied. How far afield one may go will naturally be limited by the financial ability of the community and its willingness to spend money for obtaining a good water supply. It may also be necessary to balance the cost of filtering a poorer quality, of water secured at less cost for collecting works against good water requiring no filtration which can be obtained by building more expensive collecting works. Consideration should also be given in this connection to the future needs of the community. As it and its neighbors grow, the pollution created becomes more intense and extends farther and farther out from the shore. It is likely sooner or later to menace a water supply that had proven to be of a satisfactory character. The problem involved in this consideration is to estimate the extent of future increase in pollution, its relation to intake locations and the probability of the water requiring filtration at some future time, and then ascertain what solution will best serve that particular district or city. The history of various communities indicates that the tendency is to extend intakes farther and farther out from shore as the pollution increases, and to filter the water as a last resort. This is typified by Chicago, Detroit, Cleveland, Erie, Buffalo and others. How long a time must elapse before all of the larger cities will be supplied with filtered water is problematical, but when it is remembered that three cities, each with a population of half a million or more, within the last three years have undertaken to purify their entire supplies in this manner, it seems probable that within a short time all cities of this size or larger will construct similar treatment works.

Considering the question of intake location by itself, the factors to be considered are as follows:

1. Location of the mouths of streams and sediment and pollution carried by them.
2. Depth of water and character of lake bottom, both as to their effects on the quality of the water and suitability as to foundation for an intake structure.
3. Direction of wind and currents, and their effect in stirring the lake bottom and conveying sediment and pollution from point to point and out from shore.
4. Temperature, color and effect of stagnation or stratification of water.

5. Sources of pollution; as sewers, water front industries, and water-borne traffic; and the amount of pollution.
6. Freedom from ice trouble during the winter months.
7. Interference with navigation and possibility of damage from passing boats.

The above factors are stated as applying to intakes in lakes and harbors, but most of them apply in large measure to intakes in streams having small variation in water level. Water from near one bank of a river is often found to have a better quality than when taken from near the other. Permanency of river-bed is to be considered for some streams, and also the velocity of current in various parts of a stream. Whenever it is found desirable to take a water supply from a stream having a relatively steep grade, ice troubles can sometimes be lessened by placing the intake as far upstream and as near quiet water as possible.

II. TYPE OF INTAKE STRUCTURE

Intakes are usually, although not always, protected by means of a structure called a crib, and the need for such a structure decreases as the depth of water exceeds 50 feet. There are two general types of intake structures, the submerged crib and the exposed crib. The greater number of intakes on the Great Lakes are of the submerged type, but a few of the largest cities have the exposed type, namely, Chicago, Detroit, Cleveland, Buffalo and Montreal. The old intake system at Milwaukee has an exposed timber crib over a lake shaft some 3000 feet out from shore, and cast-iron pipe lines extend about 5000 feet farther. The arrangement is essentially a combination of the two types, although no water is drawn from the crib over the shaft.

When water must be taken some distance from shore, the simplest form of intake to furnish a small supply is provided by laying the pipe directly on the bottom of the lake and by placing an elbow and short section of vertical pipe at the end. This end section is maintained in position by placing a circular weight, as a car wheel, over the vertical section. This simple and inexpensive arrangement can be taken advantage of whenever it becomes desirable to secure samples of water for testing from various locations and at different depths at all seasons and from large lakes that are navigable but a portion of the year. In this case a line of small pipe with screwed joints is extended to the point from which samples are desired, and a small

pump located on shore draws water through it continuously for sampling. The line is easily moved and shortened and lengthened, and the vertical pipe can likewise be shortened or lengthened so that samples may be secured at various points and depths.

Comparing the two types, there is no question but that the exposed crib costs more. Standing above the water surface, it is subject to wind and wave action, river currents and to ice pressure, and consequently it must be made massive to withstand these forces. Excepting at Montreal, the exposed cribs on the Great Lakes form the inlet to a tunnel conveying the water to the shore. In order to construct the lake or river shaft, a crib of some form is almost always essential, and it is a natural step to make it a permanent structure, and this also facilitates future extension of the tunnel if necessary. Due to the cost of an exposed crib, the probable need of constant attendance on the crib after completion, and the cost of the tunnel, this form of crib can be afforded only by the large cities as noted above. An exposed crib also permits water to be drawn from different levels, although this feature is less often taken advantage of now than formerly. It has been maintained that the economy of the exposed crib "may be doubted," and the arguments advanced in support of this position were well stated in a report made about 1896 on the Cleveland intake by Messrs. Rudolph Hering, George H. Benzenberg and Desmond Fitzgerald, recommending a submerged crib chiefly on the ground of expense and trouble with ice. Their recommendations were as follows:

> We have considered the form of the intake at the terminus of the new extension, and we firmly believe that a submerged crib should be adopted. Where a crib is designed to extend above the surface of the lake for the purpose of giving access to the tunnel and to draw water at different levels, it must be of most substantial construction. Small and weak cribs have proved a constant source of anxiety and expense and even where a very large structure is used, surmounted by heavy masonry walls, it acts as an obstacle to the free passage of ice, which in consequence piles up in great masses and to considerable depths, interfering with the free access of water to the ports. Such a structure entails heavy expenditure, both in original construction and maintenance. It is an impediment to navigation and must be supplied with a lighthouse.
>
> A submerged crib, on the other hand, say 10 feet in height, in 53 feet of water, allows the free passage of ice on the surface, and uninterrupted access for the water. In a lake the size of Lake Erie, stagnation effects could hardly occur in such a position and the water will always be of excellent quality near the bottom. We, therefore, recommend a submerged crib for the intake.

It is important that the velocity of the water, when it enters the crib, should be reduced to but 3 or 4 inches per second, and that the area of ingress be sufficient to produce this result. The evident consequence will be that less floating matter will be drawn into the crib.

Notwithstanding the above recommendation for the construction of a submerged crib, it should be noted that Crib 3, built subsequent to this report, is an exposed crib.

About 1908, the City of Buffalo constructed an exposed intake crib through which the present supply of water for this city is now obtained. This plan was adopted after extensive and exhaustive examinations and reports had been submitted by a number of distinguished engineers, and the subject of submerged cribs as considered in connection with this project was referred to in Engineering Record October 18, 1908, as follows:

A submerged intake crib was considered, in comparison with one surmounted by a structure rising above the surface of the water, with the result that the latter type was selected. The advantages of a submerged intake are much reduced by the shallowness of the water and by the dangers resulting from the proximity of the site to a channel carrying considerable traffic. Unforeseen contingencies introduced by the action of ice after it breaks up in the lake also offers a menace to a crib entirely submerged. An intake surmounted by a structure rising above the surface not only eliminates these dangers, but also permits control of the inlet ports.

Except as influenced by the relation between population and financial ability to incur the expense, it cannot be said that population enters into the question of type of intake to be used. Toronto, with a population of 549,429 (1925), is the largest city having a submerged crib; Milwaukee, with 500,000 (1925) is next, with Toledo, with 300,000 (1925), and Erie, 120,000 (1925) following. Buffalo, with 506,775 (1920); and Montreal, with 556,000 (1925), are the smaller cities having an exposed crib. Of course present population does not bear so directly on the question as does the population at the time the intakes were constructed; thus, Detroit had about 289,000 in 1900 when a new supply was being considered, and over 405,000 in 1907 when the present intake and tunnel were put into service.

III. SUBMERGED CRIBS

Submerged cribs are used in all depths of water. The shallowest are Orillia, Ontario, 8 or 9 feet; Toledo, Ohio, 11 feet; Monroe, Michigan, 12 feet, and Niagara Falls, N.Y., 18 feet. The deepest are at Oswego, N.Y. 80 feet, and Toronto, 100 feet.

The character of bottom varies from rock and sand and gravel to shifting mud. Were it desired to refer to the same stage of water, some correction should be applied to these and other depths mentioned herein. There is considerable variation in the construction of submerged intakes. The larger ones have usually taken the form of a square or octagonal timber crib having a solid floor, divided into compartments by the cross timbering. The conduit is carried through the cribbing above or below the floor to the central compartment or well terminating in an elbow, or in some cases, as at Erie, the conduit is carried across the entire crib, and a tee is provided at the central well and the portion beyond is closed with a blank flange outside the crib. The crib is towed out to its final location and sunk, and as many of the compartments as necessary to hold crib down are filled with broken stone or concrete, or both. Where the pipe line is laid on the lake bottom, the crib also rests on the bottom and where the pipe is placed in a trench, the crib is set the necessary distance below. The top of the crib is about 6 to 8 feet above the bottom of the lake and rip rap is usually placed against its sides. The central well and often the four compartments joining at the four sides of the well are covered with a grating of plank placed on edge and spaced about 2 inches in the clear. These planks may have a uniform thickness, or one edge may be thicker than the other, in which case the thinner edge may be set on the lower side of the grating. As samples, the old Milwaukee crib is octagonal, rests on the bottom and has an elbow inlet, while the Erie, Pa., crib is 40 feet square, the bottom is placed about 11 feet below the lake bottom and a tee is provided at the central well, the pipe extending through the crib. At Toronto, there is a tee at the central well, but the pipe is carried above the crib. The opening is protected in case of the older intake by a cone consisting essentially of 28 1¼-inch round bars spaced equally around the circumference, and the newer intake by a stool plate supported 30 inches above the lip and guarded by 1¼-inch round rods spaced 8⅛-inches on centers.

At Sarnia, Ontario, the crib is a truncated oblique pyramid, and the base is essentially triangular with one angle very acute. This provides a long nose-like effect which points upstream. The ends of the two 24-inch pipe are inside the crib, and terminate in the rear face near the top. The crib was built of timber, sunk to river bed, and then filled with concrete.

At Monroe, Michigan, a still different arrangement is used. A

truncated rectangular pyramid, 27 feet by 28 feet at the base and extending 5 feet above the river bottom was built of concrete in place. It contains a central well 6 feet square. This is protected by a 3-inch plank deck supported by 3-inch pipe columns, the clearance above the well being about 6 inches.

While information is meager, a former not uncommon type of intake appears still to be used for some of the smaller water supplies. This consists of a cast iron or steel hood or cage, without protecting crib work, placed over the inlet elbow or toe of the pipe line, the hood being pierced with a great number of holes $\frac{1}{2}$ inch or more in diameter.

Screens. Fine screens when provided are usually placed in a well on shore. These screens were formerly removable or stationary but more recently the traveling type has been introduced. Toronto has installed stationary screens of the traveling type due to the ice troubles, and the recently opened system of water supply for the Border Cities opposite Detroit has traveling screens. Toronto uses a copper mesh having $\frac{3}{8}$-inch square openings. The old Windsor, Ontario, water supply has double screens, stationary, with $\frac{1}{4}$-inch mesh. At Monroe, Michigan, a 1-inch mesh is used.

IV. EXPOSED CRIBS

Due to the tremendous forces that an exposed crib must be prepared to withstand, there is a limiting depth beyond which any economy this type may have will disappear. While no rule can be laid down on this point that will apply in all cases, it is interesting to note the conclusions that were reached by engineers at Milwaukee as reported in the Engineering News, June 18, 1914. These were that "The principal reason for the Milwaukee intake arrangement is that the crib will be in 40 feet of water which is considered about the limit of depth in which the shell for such a structure can be placed economically, while a greater depth is desirable for the source of supply and is within reach of pipe lines." As constructed this crib is of the submerged type and is located in 65 feet of water.

Of existing exposed cribs, Nos. 3 and 5 at Cleveland are in the deepest water, about 49 feet. The Lake View crib, Chicago, in about 26 feet, and the Buffalo crib, in about 23 feet at low water, are in the shallowest water.

An exposed crib consists essentially of a central well enclosed by massive walls of sufficient thickness to give the required strength and stability. The inlet to the conduit which will carry the water to the

shore is from the well, and ports through the crib walls admit water to the well. These cribs are built on shore, launched, towed to position and sunk, the bottom having been leveled off by dredging.

There has been considerable change in the design of intake cribs since the earlier ones were constructed. Two-mile crib, Chicago, completed in 1867, was pentagonal with 58-foot sides and a height of 40 feet. The central well was of similar shape, the walls of crib being 25 feet thick and the space between divided into seven compartments and filled with rubble during sinking. This crib was built entirely of timber. The Hyde Park, or 68th Street crib is of similar construction, but hexagonal in shape. These two intakes are peculiar in that they are protected by a heavy breakwater, the one at Two-Mile having an opening for tugs to enter, while at Hyde Park, as a result of serious trouble from ice entering the opening at Two-Mile, no opening was provided and ports were built through the breakwater. Crib 4, the first exposed crib at Cleveland, built prior to 1890, is also pentagonal and constructed entirely of timber, and without a breakwater.

The Twelfth Street or Four Mile crib, Chicago, built during 1890–1894 and the Lake View crib, Chicago, completed in 1896, mark a change in construction. The one circular and the other a 12-sided polygon had a polygonal base of heavy timber grillage through which the ports pass. On this base were two concentric steel shells with radial bulkheads forming compartments which, in the case of the Four-Mile crib, were filled with concrete. The Carter M. Harrison crib built about this time was also of this design. Crib 3 at Cleveland, built about 1898, was of similar construction except for the bottom grillage, and rubble was used for filling.

The Detroit intake crib, built during 1905–1907, was constructed entirely of timber and the compartments filled with concrete. It has an elongated octagonal shape.

In 1909 and 1910, Buffalo built a crib having two concentric steel shells with no bottom. It was divided radially into compartments. To obtain bouyancy for floating out to position, a number of compartments were closed at the bottom with timberings. The crib was landed on a concrete foundation ring resting on rock and then filled with concrete.

The Wilson Avenue intake system, Chicago, completed around 1918, presents another variant in crib design. There were two concentric steel shells with radial compartments, but no floor. The

bottom of each shell had a cutting edge. For buoyancy the ports. were bulkheaded and buoyancy tanks built between the two shells. When this was towed to position and sunk the steel shoes entered the clay and sealed the bottom.

The intake shaft of exposed cribs is usually extended from the lake bottom to above the water level by an intake cylinder usually built of steel. The ports in this cylinder are provided with gates and generally with screens. The ports through the crib may be provided with gates, as at Buffalo, though usually left ungated. At Chicago stop-log guides are provided. The intake cylinder of the Wilson Avenue crib, Chicago, is formed of reinforced concrete and does not come to the water surface. Screens extend from the top of the cylinder to above the water surface and the water flows through the screens into the shaft. At the Detroit intake the upper portion of this cylinder was disconnected from the lower section near the bottom of the well after completion but before the inake was placed in service, and the removed portion is in storage on the crib and held ready to be reset whenever it is found necessary to dewater the tunnel. A similar arrangement is used at Crib 3, Cleveland, except that the cast iron inlet cylinder stops at about the level of the upper tier of ports. There are 4 steel cylinders 7½ feet long stored in the crib for use in closing off the intake shaft.

The exposed cribs may be, and generally are, provided with a more or less elaborate superstructure with living quarters for attendants.

While no attempt has been made by the writer to present any details of design as they relate to the stability of the structure, it is believed that opportunity should be taken to call attention to the great forces occasioned by storms and ice that exposed cribs must withstand. Ice may be expected to ground in 30 feet of water and probably somewhat deeper under some circumstances. During severe and stormy winter weather, spray will be thrown to considerable heights, and as this will freeze as it falls, large quantities of ice will accumulate on such structures as intakes, light-houses and piers. It has been stated by Captain D. D. Gaillard, Corps. of Engineers, U. S. A. that,

In planning structures which are to be exposed to wave action it is very desirable to secure in advance data upon the following subjects: frequency and violence of storms, the direction and maximum velocity of storm winds, "fetch," the direction of wave travel, the maximum height and length of storm waves, whether or not waves break in advance of or in the vicinity of

the site during storms or governing depth in the vicinity, the configuration and character of the bottom, the fluctuation of water level, and the movement office.

Waves may be expected to reach a height on the larger lakes of at least 20 feet, and the movement of material on the bottom of the lake due to storms will extend to a depth of about 50 feet.

V. LOCATION OF PORTS

The location of the ports above lake bottom varies with the crib. The minimum appears to be about 4 feet from bottom of port to lake bottom, as at Detroit and Buffalo, and this distance is necessary to exclude forms of animal life that spend most of their lives on the bottom. Referred to the water surface, only a few cribs have shallow ports. At Buffalo the depth from mean lake level to top of port is about 9 feet, while for the inlets of the inlet cylinder is about 3 feet less. At Detroit, the depth from mean river level is 6 feet. There are, however, three tiers of ports, the lowest having a depth of 20 feet. The Two-Mile crib, Chicago, has two ports with tops at elevation −1.5 and −2.0 respectively, city datum, with two others at elevation −14.0. The three ports of the auxiliary intake are at about elevation −4.0.

An exposed crib permits drawing water from different levels. However, while ports are placed at two or more levels in some of the cribs, the information at hand indicates that water is drawn from all levels and not from the particular level which it may appear will give the best water at the time. Openings in the inlet cylinder are usually placed at a higher level than the ports.

VI. ICE TROUBLES

Ice is a source of much anxiety and trouble for those who maintain intakes located in the same latitude as the Great Lakes where severe winter weather must be contended with, and it may reduce greatly the quantity of water coming through the intake and even completely cut off the flow at times. Ice occurs in three forms differentiated by method of formation, portion of the water in which it is formed, and its structure; namely, sheet, frazil and anchor ice. Sheet ice forms on the surface of the water, the increase in thickness taking place on the under side of the first thin sheet of ice formed on the surface of the water. Sheet ice may be broken up into cakes which drift with

the wind and current, due to wind action and changes in water level. Frazil ice, also called "needle" or "slush-ice," is frequently confused with or called anchor ice, although the method of formation is different. Frazil ice is a surface formed ice and consists of needles or spicules of ice which form when the surface of the water is cooled below the external freezing temperature, but are prevented from forming into sheet ice by agitation or by the velocity and currents in the water. It is always formed in an open channel or lake and ceases to form when the ice sheet forms.

Anchor ice forms on the bottom of a body of water as a result of the cooling of the bottom by radiation. It may grow by attaching to itself frazil ice carried down by currents. This form of ice has proven very troublesome in Canadian rivers, as very large quantities may be released from the bottom of these streams in a limited time. Sheet ice and frazil ice are sources of stoppage for lake intakes. Sheet ice causes annoyance chiefly after its breaking up, for it is then carried by wind and current and may form jams or packs which restrict the flow. Mr. W. J. Barber reported in the "Engineering News," June 19, 1913, that the Chicago intakes at times of severe storm have experienced heavy ice jams, the ice piling up on the windward side for 10 to 25 feet above the surface and down to the bottom of the lake and causing more or less obstruction to the flow. Information at hand does not indicate whether such jams are more serious at the intakes nearer shore than those farther out, and except for work at the crib during such jams there may be no feasible means of preventing trouble from this source.

In the winter of 1915 trouble from floating ice at the Detroit intake became so serious that the clogging of the ports lowered the water level in the shore basin by 4 feet, reducing the capacity of the intake about 30 per cent in less than an hour. The crib is so situated at the upper end of the Detroit River that it is exposed to the ice floes and waves of Lake St. Clair. To prevent future trouble, a V-shaped fender of piling and timber sheeting was built upstream from the crib. The sheeting extends from the river bottom to extreme high water, the wings diverging at 90 degrees and their down-stream ends are 25 feet from the nearest point of the crib and 4 feet below its upstream edge. It is braced against the crib, and although it has been necessary to make repairs annually, it has served its purpose well.

During the winter of 1904–1905, the writer measured the ice

formation in Lake Erie opposite Presque Isle, Erie, Pa., and observed that the ice formed a ridge about 18 feet high parallel with the shore line and in about 15 feet of water, and that accumulation of ice grounded in many places in more than 30 feet of water.

Frazil ice causes trouble chiefly by adhering to the screens, racks and port openings and gradually closing them completely. Under conditions favorable to producing large quantities of frazil ice, it may enter the ports and completely fill the intake well. The most serious trouble with water intakes occurs at night when it is the most difficult to combat. Professor Barnes in his "Ice Formation" states

> A dull, stormy day with a wind that blows against the current, is productive of the greatest amount. This is the result of the surface agitation together with the rapid extraction of heat. A bright, sunny day, although very cold, does not show much formation, on account of the absorption of the sun's rays near the surface, offsetting the cooling effect of the air. At night, under a clear sky with wind agitation, a large amount will be formed, depending on the temperature of the air. In this case, both conduction to the air, and radiation from the bottom and volume of the water are operating.

Various remedial measures have been tried from time to time, and it has been observed that the depth of port opening below the surface has a marked effect. At Marquette, Michigan, the intake previous to 1912 was in 23½ feet of water, and interference to flow from frazil ice stopping the upturned elbow of the intake was experienced. Since being moved into deeper water no trouble has occurred, although there is a ⅛-inch mesh copper screen over the port. It is difficult to fix a minimum depth at which ice trouble will not occur, as this appears to be governed by local conditions and velocities through ports. Monroe, Michigan, reports trouble with 12 feet depth of water, while Toledo with 11 feet reports none. Erie, Pa., with depth of 32 feet, and Gary, Indiana, with 33 feet report no trouble, while Windsor, Ontario, with 42 feet and Sarnia, Ontario, with 40 feet report trouble. Again, Sault Ste. Marie, with a depth of 50 feet, Milwaukee with 67 feet, and Kingston, Ontario, with 60 feet, report no trouble, while Oswego, New York with 80 feet has experienced difficulty once or twice a winter. The above figures refer to depths of the bottom of lakes and channels. It will be noted that ice troubles for some of the deeper intakes are not confined to those located on rivers.

Back pressure on the intake port for submerged cribs is used more or less effectively to remove the adhering frazil ice. Steam and

compressed air have also been used. At Prescott, Ontario, (population 2750) the water in the pump well is heated and forced back through the intake. Dependence in some cases is placed on sufficient storage to alleviate conditions and tide over the demand until natural causes assist in establishing normal conditions of flow.

Ice trouble at Chicago occurs generally following sub-zero weather, especially before sunrise and during periods of maximum demand. The ice is handled by dislodging with pike poles, steam hose and by shocks from explosions of small charges of dynamite. The screens over the inlets to the intake shafts are also removed in winter. Toronto had serious trouble when using stationary screens at the shore well, but since the installation of traveling screens there has been but little trouble on the whole and then only during severe winters.

For many years Detroit suffered from the accumulations of ice at the intake. In 1858 its strainer at the end of the intake pipe was a boiler plate cylinder 9 feet in diameter and 10 feet high, with a dome tap, perforated with ½-inch holes, 144 to the square foot. This was set near shore in 34 feet of water in a river current of about 3 miles per hour. Ice caused serious stoppage and ample reservoir capacity prevented a shortage of water. Various means were tried to improve the situation and these included a swing door on the downstream side to be opened when ice formed on strainer; substituting a wood strainer for the metal one; enclosing a considerable area with a line of booms so that ice may form inside; building a submerged timber platform over the strainer; extending the intake farther into the river and increasing the strainer area by adding to the number of strainers; and finally, laying a second intake pipe with wooden slat gratings on down-stream side of strainer. The laying of the second pipe apparently gave some relief.

New works were built in 1877 at the present site and a large intake box supplying a 5 feet pipe was placed at right angles to the current about 1000 feet out from shore. The strainer consisted of wood slat on the downstream side. Serious trouble occurred from time to time and in 1884 a second pipe 6 feet in diameter was laid, two strainer boxes of a similar construction to the first were placed at the end, and a self acting relief valve provided. Ice continued to close the supply at times, and in 1890 a third inlet pipe was laid, and the strainer box was placed parallel with stream flow. For a period of 10 years there was entire freedom from accumulation of ice, but it was later dis-

covered that this was due to a breakage in two of the lines near shore. On repairing the breaks the troubles were experienced again and every other slat was then removed from the cribs. An emergency valve which had been but recently installed was opened in the winter of 1901–1902 and even then ice interference put the city on short supply. Trouble was also experienced with frazil ice in the settling basin for the first time.

With the present exposed intake and connecting tunnel, ice trouble has been experienced from time to time. Grates over the intake ports were omitted to reduce any clogging of the ports. In 1923 traveling screens were installed in a special screen chamber on shore, and these remove the slush ice coming through the tunnel. The behavior of flow is such at times as to indicate a partial temporary stoppage within the intake or tunnel. A supply of steam has been provided in the screen well to reduce the accumulation of slush ice above the screens.

In an effort to reduce the tendency of frazil ice to be drawn into intake ports, the velocity of flow through the ports has been reduced on various intakes. As low velocities are necessary in order not to overcome the buoyancy of frazil ice, this reduction in velocity has probably not been carried far enough. Chicago designs port openings for a normal velocity of 1 foot per second, though maximum velocities reach 3.63 feet per second. Crib 3 at Cleveland is designed for a maximum of ½ foot per second, the ratio of port area to tunnel being 8 to 1; Toledo has a maximum of ½ foot and a mean of 0.3 foot per second. At Buffalo the ratio of port opening to tunnel area is about 3 to 1, but the velocities are not known to the writer. Toronto has a maximum intake velocity of 2.88 feet per second and a mean of 1.48 feet per second. Detroit's intake was designed for a velocity of ¾ foot per second for the assumed maximum of 150 m.g.d. This maximum is exceeded now and the port velocity will probably at times in the future equal or exceed 2 feet per second.

In the design of Detroit's additional water supply the idea of using a fore-bay or lagoon is being considered. It is a matter of common observation that frazil ice does not form when the water is sufficiently quiet to permit the formation of the ice sheet. This has been noted frequently in power plant installation having large fore-bays. The reason for using a lagoon intake is to reduce velocities and wave action so that an ice sheet will form readily at all times, and to locate the inlet so that frazil ice that is formed in the river will

be excluded as far as possible. Experience with models indicates that careful consideration must be given to the design of a fore-bay to prevent stagnation in pockets, and to insure fairly uniform low velocities of entrance to the bay and of approach to the intake.

There are few troubles other than with ice, although at Sarnia, Ontario, sand and driftwood may enter the intake pipe at any time of the year and at times cause complete stoppage.

VII. MAINTENANCE AND OPERATING COSTS

Information is not at hand as to actual maintenance and operating costs, but there can be little question but that a submerged crib costs less for these items than an exposed crib. As a matter of precaution a submerged crib should be inspected from time to time by a diver in order to ascertain its condition and to make any necessary repairs, but it is a fairly safe guess that inspection usually follows some indication of trouble. Unless damaged from operations incidental to water-borne traffic or from possible ice jams and scour of bottom, a well constructed and securely anchored crib should require little maintenance work. Exposed cribs are subject to the continual battering and buffering of wind, wave and ice, which tends naturally to increase the necessary maintenance work.

Operating costs appear to be largely the result of ice troubles. It may be a question how much is chargeable to the intake itself, since the conditions or its construction may be such as to transfer the trouble from the intake to a screen well on shore. However, considering the function of the intake structure to be the protection of the intake system from the gross troubles arising from the water it is located in, it seems reasonable to charge operating costs arising from ice, sand and driftwood to the intake.

It is impracticable, if not impossible, with a submerged crib to do much to combat the trouble at time of greatest need, especially with ice. An exposed crib affords a vantage point from which to conduct operations and so will be used to the fullest extent. The experience at Chicago illustrates this. The operating force may vary from the normal force of one crib keeper and two assistants to some 25 to 30 men in winter.

On exposed cribs it is necessary to maintain a light during the navigation season at least. While the light may really need little attention, it is usual to have a crib-keeper. Detroit has a keeper during the day during the navigation season, chiefly to keep off intruders, and has no one during the winter time.

TABLE 1

Data on obsolescence of intakes

CITY AND INTAKE	TYPE OF CRIB	INTAKE CONDUIT	CRIB CONSTRUCTION		INTAKE ABANDONED	REMARKS
			Begun	In service	Date and Cause	
Buffalo:						
Old................	Exposed pier	Tunnel 4½ feet x 10¾ feet ?	1872±	1875	About 1910. Increasing pollution	Pier extended about 1896, and a second tunnel 8 feet in diameter driven
New..............	Exposed	Tunnel 12 feet x 12¼ feet	1908	1910	Still in service	
Chicago:						
Two-Mile..........	Exposed	Tunnel 1–5 feet diameter 1–7 feet diameter	1865	1867	Still in service; to be abandoned on completion of new tunnels at this point drawing water farther out	Wood superstructure replaced by brick in 1895
Two-Mile Auxiliary	Exposed	1–7 feet diameter	1895	1896		
Four-Mile..........	Exposed	Tunnel 8 feet diameter	1889	1892	Still in service	Built to increase supply and secure better water
Hyde Park (68th Street)...........	Exposed	Tunnel 7 feet diameter	1892	1894	Still in service; superstructure rebuilt of masonry in 1896	To supply Hyde Park district
Lake View.........	Exposed	Tunnel 6 feet diameter	1892	1896	1924. Demolished; tunnel supplied from new Wilson Avenue crib 1 mile farther out	To supply Lake View district

Carter H. Harrison	Exposed	Tunnel 10 feet diameter	1896	1899	Still in service	
Ed. F. Dunne......	Exposed	Tunnel 14 feet H.S.	1909?	1911	Still in service	
Wilson Avenue.....	Exposed	Tunnel 13 feet H.S.	1915	1918?	Still in service	Built to secure better and increased supply for Lake View
Cleveland:						
Crib 4............	Exposed	Tunnels, one —5 feet One—7 feet		1874(?)	1904. Completion at Crib No. 3 giving better water	5 feet tunnel later enlarged to 7 feet and both supplied from Crib No. 5
Crib 3............	Exposed	Tunnel 9 feet diameter	1898	1904	Still in service	Built to secure better water
Crib 5............	Exposed	Tunnel 10 feet diameter	1911	1917	Still in service	Built to increase supply
Detroit:						
Orleans Street.....	Submerged	30-inch pipe	1858		1881. Completion of new works	Extended in 1871 because of ice. Built to reduce ice troubles
	Submerged	36-inch pipe	1873		1881. gave better supply	
Water Works Park.	Submerged	60-inch pipe	1877		1907. Completion of exposed in-	
	Submerged	72-inch pipe	1884		1907. take giving larger and purer supply	Built to reduce ice troubles
	Submerged	72-inch pipe	1890		Used as emergency supply	Built to reduce ice troubles
Present Intake.....	Exposed	Tunnel 10 feet diameter	1903	1907	Still in service	Built to secure better supply

TABLE 1—*Continued*

CITY AND INTAKE	TYPE OF CRIB	INTAKE CONDUIT	CRIB CONSTRUCTION		INTAKE ABANDONED		REMARKS
			Begun	In service	Date	Cause	
Erie:							
Original Intake....	Submerged	Pipe 51 inches and 48 inches	—	1868	1896.	Increasing pollution	
Second Intake.....	Submerged	60-inch pipe	—	1896	1908?	Increasing pollution	
Third Intake.......	Submerged	60-inch pipe	1904	1908(?)	Still in service		Pipe line is an extension of that to second intake
Milwaukee:							
	Submerged	36-inch pipe		1874	1895	Pollution and inadequate supply	
North Point*......	Exposed Submerged	7½-foot tunnel 2—60-inch pipe	1890	1895	Closed but held in reserve		Built to secure larger and better supply
Linwood Avenue...	Submerged	12-foot tunnel	1914	1918	Still in service		Built to increase supply

* Pipes go from exposed crib to submerged crib farther out.

VIII. DEPRECIATION AND OBSOLESCENCE

Figures on depreciation are not available, but the data indicate that it is more a question of obsolescence than depreciation since no crib has as yet reached the limit of useful life due to depreciation. A statement in the Engineering News-Record, April 29, 1920, follows: "Chicago has seven cribs and it is proposed to add one more. Four are in good condition, but three need repairs." The Lake View crib, Chicago, was demolished in September, 1924. This crib was sunk in position in 1892 and the system put in service in 1896, making a maximum service of about 28 years. It was demolished because of the completion of the Wilson Avenue crib and tunnel which made this crib unnecessary.

There are three factors making for the obsolescence of an intake: Necessity for increased capacity; increasing pollution at existing location making it necessary to draw water from a less polluted location; public demand for a better quality of water than is obtainable from the existing intake.

There is another factor which will increasingly affect the question of obsolescence, and that is the treatment of sewage which is receiving increased attention. As the volume of sewage treated increases and better methods of sewage disposal are put into operation, the degree of pollution of the water of the Great Lakes may decrease and so possibly obviate the necessity of abandoning intakes because of polluted water.

Table 1 gives information regarding obsolescence.

IX. INTAKE CONDUITS

Intake conduits are of two types, pipe lines and tunnels. At Milwaukee a combination of the two are used, tunnel for the inshore section and pipe for the remainder.

The choice between tunnel and pipe-line, and between different materials, depends on the cost of construction and maintenance, the nature of the bottom, and the relative durability. Due to cost, tunnel would be prohibitory for practically all the smaller works, while for large intakes tunnel may be cheaper. There is minimum size below which it is not feasible to drive tunnel because of the cramped working space and consequent relative increased cost, and this may be taken as 5 feet finished diameter, possibly 4 feet or the equivalent area. Tunnel is, therefore, generally limited to the larger intake

conduits, but along the south shore of Lake Erie where the surface of the rock is shallow, the preparation of a trench to receive a pipe line is costly, and it is sometimes necessary to construct a short tunnel from near the short to a point beyond which a pipe line can be maintained. As to durability, there is no question but that a properly constructed tunnel will last longer than a pipe line with the possible exception of cast iron.

With few exceptions, tunnels have been built only in connection with exposed intakes. The Linwood Avenue intake of Milwaukee, however, has a 12 foot diameter tunnel extending out about 6,500 feet to a submerged crib in 65 feet of water. At Gary, Indiana, population 55,000 in 1920, there is a submerged crib about 1½ miles from shore and an intake tunnel, 6 feet high, horse-shoe shaped, which was built about 17 years ago.

The size of conduit will be largely governed by the permissible loss of head from intake to pumps, which in turn is dependent upon the available suction lift and the cost of constructing a deeper pump-pit and suction well and pumping against higher heads as compared with the cost of a larger conduit. For long intake conduits this will indicate low velocities and larger conduits. For operation in connection with a filtration plant, a greater loss of head is usually permissible, as the low-lift pumps can be placed relatively low at a moderately increased cost for construction and operation. The past experience of growing communities, in addition, indicates the desirability of building a larger intake conduit than required by the needs of the immediate future, particularly if a tunnel.

Pipe conduits may be cast iron, wrought iron, steel, wood-stave or reinforced concrete, and cast iron and steel are the usual materials. Wrought iron was formerly used where steel would now be used. Wood-stave was used on one of the old intakes at Erie, Pa., and also at Toronto, and while available information does not note the use of reinforced concrete pipe, there appears to be no reason why it could not be as successfully used for some intakes as for sewer outlets.

There appears to be no reason why the relative durability of the several materials should be any different when used for an intake conduit than for a conduit on land. A 60-inch wrought iron pipe, ½ inch thick, coated with red lead was laid in the Detroit River in 1876, extending out from shore 1000 feet to about 27 feet of water. It was laid directly on the river bottom and when taken up in 1923 was found in good condition, and a considerable portion of the red lead coating

was intact. Steel pipe is lighter and easier to handle than cast iron, but is also more easily disturbed when laid, unless anchored down or placed in a trench and covered.

As to size, 60-inch appears to be the largest cast iron pipe that has been used. This size was used for 1½ miles of harbor portion of the conduit at Erie, Pa., maximum water depth being 26 feet, and at Milwaukee for the two parallel pipes making up the outer 5000 feet of that conduit, the depth increasing from 40 to 60 feet. Toledo has two 48-inch lines in shallow water, and other smaller cities have 30 and 36-inch pipe in water 50 to 80 feet deep at the intake. The largest steel pipe is reported as 72-inch. Toronto has two lines, the maximum depth of water being 100 feet, but the larger part of this was laid in much shallower water. Likewise, Montreal has two lines, with depth at intake of 28 to 30 feet, and the river current having a velocity of 6 to 8 miles per hour.

Intake pipes have been laid directly on the river bottom and also in a dredged trench. While the latter is more expensive it is preferable as the pipe is then protected from wave action, scour, injury from dragging anchors, and, in shallow water, from boats. The depth of cover should not be less than 4 feet and greater cover may be desirable in some locations and near shore.

Many different designs of pipe joints for submarine work have been proposed and several have been used. The recent experience in New York harbor has demonstrated that flexible joints can be made tight, even when laid under severe conditions. The submarine joint for steel pipe which was designed and first used by the writer at Erie, Pa., has been used quite generally on the Great Lakes and has proven satisfactory. A description of this joint appeared in Engineering Record, October 14, 1905.

The experience of Detroit with its old intake conduits illustrates the dangers of an exposed conduit in water 30 feet or less in depth, and a valuable contribution by Mr. C. W. Hubbell covering this was published in the University of Michigan Technic, 1903. A 60-inch wrought iron pipe was laid in 1876 extending out 1000 feet from shore. To alleviate ice troubles a second pipe 72-inch was laid in 1884 and in 1890 a third pipe, also 72-inch and extending out 1500 feet These pipes were examined by divers about ten years later, who found that the joints of the 60-inch pipe were leaking badly and that the two 72-inch pipes were broken off completely at a point near shore. In one case there was a space of 4½ feet between two consecutive lengths of pipe; and in the other, two sections, each 25 feet long,

had been carried away entirely and were found some 20 or 30 feet downstream from the pipe line. The indications were that at least one of the pipes had been broken by dredges which had anchored in that vicinity shortly after the pipe was laid in 1890.

The intake tunnels on the Great Lakes have been driven through rock or through the overlying material, depending on conditions and probable cost. This overlying material is generally a blue clay which is usually favorable for tunneling. Many of the Chicago tunnels and the tunnels at Detroit, Gary and Cleveland were driven through this material, and gas in appreciable quantities was encountered at Cleveland. Compressed air without a shield has been employed usually, but a shield was used on the last tunnel driven at Cleveland. The greater part of the first Milwaukee tunnel was driven through a hard rock-like clay, and the Linwood Avenue intake tunnel through a brown shale. The Buffalo tunnel was constructed in rock at a depth of about 63 feet and the Wilson Ave. and the 73rd Street tunnels, Chicago, were driven through a limestone at a maximum depth of 140 feet for the former and 153 feet for the latter. A tunnel being driven at present shoreward from the two-mile crib is at a depth of 200 feet. In order to avoid the many difficulties experienced in driving tunnels through the clay, Chicago has adopted the policy of driving all its tunnels through the rock. The tunnels have generally been driven from both the shore and intake shafts, and for some of the long tunnels in clay one or more intermediate shafts have been sunk and protected by temporary cribs during construction.

Except for the Gary tunnel, which is horse-shoe shaped, all tunnels in clay are circular in sections, as are the Milwaukee tunnels. The Chicago tunnels in rock are horse-shoe or a modified horse-shoe, and the Buffalo tunnel is rectangular with an arched roof. The largest intake tunnels driven through the clay are 10 feet in diameter. The largest tunnel in rock has been constructed at Chicago, and has a 14 feet horse-shoe section. Brick has been used largely for lining the tunnels in clay, although the last tunnel in Cleveland was 10 feet in diameter and was lined with concrete blocks, and the Gary tunnel was lined with reinforced concrete. Concrete has been used for the rock tunnels in Chicago, Milwaukee and Buffalo.

CONCLUSION

The writer realizes that the space available for this discussion is so limited that only a few matters relating to this important subject can be considered here, and then only briefly. The purpose of this

paper, however, is to call attention to the importance of the intake structures in the water system, and to emphasize the necessity of giving their design and construction the most careful consideration. An intake can be seldom if ever inspected after completion, and repairs can only be made with great difficulty, except to the superstructure of exposed cribs.

DISCUSSION

J. P. SCHWADA:[3] Lake Michigan is the source of Milwaukee's entire water supply. The original intake of Milwaukee's Water Works consisted of a 36-inch diameter cast iron water pipe with flexible joints extending out on the bottom of the lake a distance of 2100 feet into a depth of 18 feet of water. The lake end of the intake was upturned so that the top of the pipe was 12 feet below the lake surface or 6 feet above the lake bottom. Because the intake pipe was not laid in a trench, a row of piles was driven on each side of the pipe line and a plank walk constructed across the top, making a wooden pier over the intake pipe to the intake crib. The outer end of the intake was protected by a pile and timber crib revetted with stone. Originally a gated enclosure was fitted above the end of the intake to enable water to be drawn in at various depths below the surface of from 4 to 12 feet. The port openings were fitted with copper screens, but the screens clogged and the entire structure above the end of the pipe was removed as being impractical.

This original intake was used during the years 1873–1895, and considerable trouble was experienced each winter through the accumulation of anchor ice at and near the intake crib. The comparatively shallow depth of water furthered the formation of ice needles which were drawn by the pumps into the open end of the intake. These collected upon the inside of the intake pipe and obstructed the normal flow of water through the pipe.

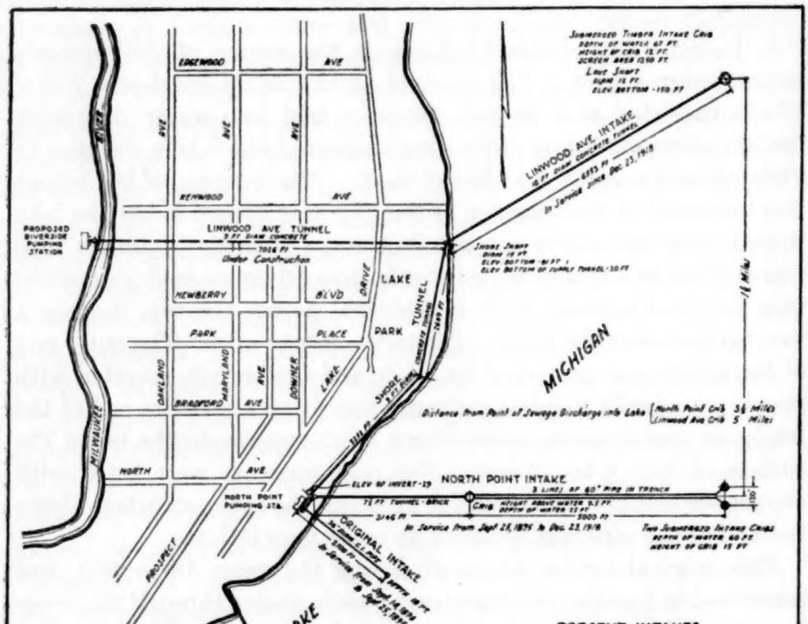
Lack of water caused in this way forced the shutdown of the pumps at various times and on one occasion during the winter of 1884 there was less than two hours supply of water on hand in the reservoir when the difficulty was overcome.

Until 1885 when the average pumpage was 13 to 15 m.g.d., corresponding to a velocity of 3 feet per second through the 36-inch pipe, the anchor ice was ordinarily dipped out of the upturned end

[3] City Engineer, Milwaukee, Wis.

of the pipe with a dip net and the water and slush ice agitated with a long pole to facilitate the flow of water to the pumps.

When such hand methods, however, were inadequate to remove the obstructing anchor ice, assistance was called for from the boats in the harbor. Live steam from the tug boilers was forced down a pipe into the intake opening and the anchor ice thus melted; but great trouble was experienced at times in getting tug boats to break



PRESENT INTAKES
MILWAUKEE, WISC.-WATER WORKS

their way through the ice of the rivers and the bay to reach the intake crib in time to afford relief.

Fearing a recurrence of this trouble, a portable upright boiler was placed upon the crib immediately above the intake opening and equipped with a steam pipe into the intake pipe. It was operated by station help during the intervals of its use. From this time on no serious trouble was ever encountered in getting rid of the anchor ice. All resistance to the flow of water through the pipe on account of the ice was overcome in from twenty to sixty minutes after steam was forced down the intake opening. During the year 1887 this intake

provided water at a maximum rate of 30 m.g.d. corresponding to a velocity of 6.5 feet per second.

Such troubles with ice were had during the years from 1873 to 1895 at which later date the second intake, known as the North Point Intake, was placed in service. This intake consists of two parts, a brick tunnel of 7.50 feet internal diameter and 3146 feet in length from the shore shaft to a lake shaft in and above water lake crib. Two parallel lines of 60-inch diameter cast iron pipe with lead joints and laid in trench extend further into the lake an additional 5000 feet into 60 feet depth of water, each terminating in an open upturned pipe, with no screen, but protected by a submerged crib. These two pipe lines lead into the lake shaft in the lake crib at a point about 20 feet below the lake surface. The ports to the lake shaft inside the lake crib are each 60 inches in diameter. The maximum velocity through the two 60-inch intake pipes, corresponding to a maximum total intake capacity of 95 m.g.d. is 3.55 feet per second and the velocity at the maximum capacity rate through the 7.5 feet diameter brick tunnel is 3.33 feet per second. At this rate there is a drop of 8 feet in the pump wells.

While great difficulties were encountered in the construction of this intake, there have been no troubles of any kind after and during the time this intake was in service, the great depth of water at the intake eliminating all possible trouble from boats and ice. However, this intake was short-lived, its capacity having been reached within twenty years.

The new intake in service since December 23, 1918, is known as the Linwood Avenue Intake and consists of a concrete lined tunnel 12 feet internal diameter which extends from the lake shore, at the foot of Linwood Avenue, out into the lake in a northeasterly direction, a distance of 6565 feet into 67 feet depth of water. At the shore end of the tunnel there is a circular shaft 15 feet in diameter which connects with the lake tunnel, which at this point is 81 feet below lake level. At the outer end, the tunnel is 150 feet below the level of the lake and terminates in a submerged intake crib by means of a 12-foot lake shaft carried slightly above the bottom of the lake. The submerged intake crib sits on the bottom of the lake immediately over the top of the lake shaft. This intake crib is octagon in shape, 80 feet in diameter and 12 feet in height, so that there is a clearance of 55 feet of water over the top of the submerged intake crib, which removes all possible danger of damage to the crib by boats or troubles

from the formation of ice. The submerged timber intake crib of the tunnel is located about five miles from the mouth of the harbor. The capacity of the intake is approximately 220,000,000 gallons in twenty-four hours at a velocity of 3 feet per second and was designed to supply the North Point Pumping Station, also a new station located on the Milwaukee River near Chambers Street (extended), and known as the Riverside Pumping Station.

The submerged crib is equipped with a wooden screen formed of 2-inch by 12-inch joists placed vertically on edge and spaced 2 inches apart. The total net area of the screen is 1250 square feet. At the maximum velocity through the screen of 0.372 foot per second, the capacity of the intake is 300 m.g.d. There have been no troubles of any kind encountered since this intake was put in service and none are anticipated.

Hugh Kellner:[4] Windsor, Ontario, had a hazardous experience with needle-ice on December 27, 1924.

We have two intakes both of which are steel. One is 30 inches diameter by 600 feet long, and the other is 60 inches diameter 550 feet long, and the latter was constructed in 1914. Both are supported at the inlet on a wooden crib, stone loaded. Each has open ends at right angles to the river, and lies in approximately 40 feet of water. No screens or grids protect the inlets and no trouble has occurred with water logged lumber.

We do at times get more than our share of weeds, however, especially just before the "fall" and of later years this trouble has become more intensified. As only stationary screens are employed these have to be closely watched at all times.

Regarding the ice trouble previously mentioned, the engineer on duty phoned me about 6 a.m. that the suction well water level was very low, and as the weather at this period of the year was particularly severe, I visualized that we had needle-ice at our 60-inch intake, this being our first experience of needle-ice with this new intake.

I immediately ordered the 30-inch intake opened, as this has been used since 1914 only as an auxiliary.

This relieved the situation temporarily, for at 7 p.m. on the same day, conditions at our suction wells indicated that this intake was also

[4] Chief Engineer, Water Works, Windsor, Ontario, Can.

attacked with needle-ice, and by 10 p.m. conditions were acute, and with no improvement in our larger intake.

The temperature at 5 a.m. was 4 below zero, with a N.W. wind blowing, later changing to the S.W., at 10 p.m. the barometer registered zero with a continued S.W. wind.

As our system is connected with the Town of Walkerville, we opened up the two connecting valves, but they also had needle-ice at their 20-inch intake, and could ill afford any water. However, this was a safety measure to help either system.

At this time we could only use one small pump and we maintained at one plant a pressure of only 12 lbs. This represented the small amount of water that filtered through the needle-ice, and the assistance from Walkerville.

At this time our Water Commission headed by the Mayor took the necessary precaution of securing the services of a diver, and a quantity of dynamite.

It will be understood that, as the river was blocked with exceedingly heavy ice, the driver could not be employed at the inlet of either intakes, therefore arrangements were made to keep the diver, his equipment and crew at our Intake Screen Well so that if a very serious fire occurred we could have dynamited our 30-inch intake a short distance from the shore to enable us get a good supply. Happily, however, we did not have to resort to such drastic measures.

Throughout the night these ice conditions prevailed, but the temperature began to rise at midnight accompanied with a change of wind from the S.W., which increased in velocity to 17 miles per hour. This velocity decreased later to 8 miles per hour, and at 5 a.m. with a rising temperature small portions of needle-ice floated into our screen well and this indicated a possible change of conditions, and later large quantities of needle-ice floated into the suction well, with the gradually rising water (the screens having been removed earlier to prevent damage). The ice was reduced by means of a steam jet, and at nine o'clock our water level was almost normal when we again resumed our usual service, but refrained from putting out our usual pressure to prevent as far as possible more ice entering the well due to increased velocity through the intake; but by noon, as conditions appeared to warrant it, we put out our usual pressure.

During the entire period of the trouble, a man was stationed at the telephone answering enquiries, and giving the necessary information relative to the care of ordinary house hot water heaters and heating boilers.

The radio at this hazardous time came in handy. The Mayor requested the Detroit Stations to broadcast information to put out boiler fires etc. Members of our fire department visited the numerous institutions to give the necessary help, advice and protection, and made preparations at the fire halls for a liberal use of chemical appliances in case of small fires, one of which did occur at a garage, and on which only chemicals were used.

Large conflagrations may have been expected at such a period due to explosions from low-water in heating boilers, but fortunately none occurred. This gave us considerable relief. The situation passed safely, but the occasion must have been an experience to many of our citizens, and a lesson to teach the value of a copious supply, which for the first time since our water works was constructed, was almost cut off due to natural causes.

Naturally some citizens gave us information as to how we could alleviate the circumstances. Much of it was totally useless, and some exceedingly absurd.

As stated before, this is the first occasion on which needle-ice has attacked our 60-inch intake. Each winter a steam jet is employed to reduce the small amount of ice that may enter the well from time to time, and which otherwise would block our screens if not reduced.

Prior to 1913 "needle-ice" was almost an annual occurrence with the 30-inch intake, but I had only the experience of two winters with this intake when our large intake was put into commission. At such times it was the custom to get a portion of supply from Walkerville, there being at that time an agreement between the two municipalities for this purpose. Therefore I cannot speak intimately of conditions which prevailed over 14 years ago, as no records were kept, and consequently no data are available.

During the last winter we had no trouble with ice. As the filtration plant of the Essex Border Utilities Commission is now in operation. we have discontinued drawing our supply from the river. We now take our supply of water from a 36-inch pipe line laid from our plant to the filter plant nearly two miles away.

Thus both our intakes will remain as at present, and will only be used in case of a protracted failure of Hydro Power at the filter plant, or for other unforseen causes.

In our particular situation, I believe the only feasible method of dealing with needle-ice would be to reverse the flow and force the cap of ice from the inlet. Someone in the past suggested to us that we might employ compressed air for this purpose, but the difficulty,

as I see it, would be the possibility of excluding all the water from the pipe, and probably causing the pipe to become buoyant and float to the surface. Therefore personally I would hesitate trying such a method.

Many years ago I understood our city engaged the car-ferry steamer to agitate the water over the intake, hoping this expedient would prove successful, but this did not improve the situation. It could scarcely be expected to do so owing to the depth of the pipe.

Methods other than reversal of flow may be suitable for our conditions, but I have no knowledge of them.

It is possible at some future date those in charge of our filter plant will have an opportunity of trying out the method they have incorporated in their construction, of reversing the flow from the coagulation reservoir into the intake to remove ice obstruction, should they have similar trouble.

Should this not prove successful, the intakes of the Windsor Water Works would be immediately put into service to guarantee a plentiful supply of water at any time. I understand Walkerville will maintain their intake, also, for emergency purposes.

Thus it will be observed that these Border Municipalities are well supplied with intakes to provide for almost any emergency at any time, due to ice or other unforseen causes.

Before closing my remarks I may point out the experience of Toronto some years ago, where on Christmas Day, 1892 the 4- and 5-foot steel intake pipes floated to the surface. This accident, as reported, was caused by the closing of the inlet by drift-weed, which used to be removed daily by an attendant who on this occasion had not made his accustomed visit the previous day. The screens were choked and pumping being continued at the pumping station, the pipe was pumped out, and the pipe floated to the surface. I understand this occurrence caused an expenditure of over $33,000.

Later on September 5, 1895, part of the pipe rose again and in settling down three joints were fractured. After repairs were completed Mr. Keating, then City Engineer, recommended the construction of an intake tunnel from Hanlons Point to the pumping station.

While compressed air may be used to advantage in a driven tunnel, the same method may not be successfully used in the case of a pipe laid on the bed of a river or lake unless liberally weighted with suitable material.

USE OF PULVERIZED FUEL IN THE WATER WORKS PLANT[1]

By Charles S. Denman[2]

Wonderful progress has been made, within the memory of the writer, in the betterment of our water works methods. This progress has been along lines of engineering, improvement in machinery, boiler room practice and in the purification of our water supplies. It is an undoubted fact that within the past five years the modern power station has undergone and is now undergoing an evolution.

The use of pulverized fuel has come into general practice by leaps and bounds not only in Europe, but in the United States. The earliest record of the use of fuel in this form was in England in 1831. Its use has been quite limited, however, until the last ten or fifteen years, but is now well known to be past the experimental stage.

In most of our plants it must be conceded that enormous waste exists in thermal efficiency. It has been demonstrated in our plant, which is not a superpower station, that this waste can be overcome and great saving effected by pulverizing the fuel rather than using the ordinary stoker or hand fired installations. The chief advantages briefly are:

Higher thermal efficiency
Wide range of fuel that can be used
Flexibility
Ease of control
Elimination of necessity for banked fires due to enormous furnace volume
Little ash and clinker
Almost complete combustion
Reduction in amount of excess air
Almost absolute control of air supply
Chimney losses reduced
When furnaces are properly operated and designed almost complete elimination of smoke
Lower furnace maintenance costs

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[1] Presented before the Buffalo Convention, June 7, 1926.

[2] General Manager, Des Moines Water Co., Des Moines, Iowa.

Automatic damper and feed control
Saving in labor
Higher boiler rating
Lower necessary capital expenditure for buildings and boilers

Low temperature carbonization of raw bituminus coal at the mines and at the larger power plants is being seriously considered and in some instances is actually in practice. It is the opinion of some writers that we are fast approaching the time when the use of raw coal will practically cease. When this time comes our cities will become healthier and more desirable places in which to live. All of which is along the line of greater efficiency and the elimination of the waste of the valuable by-products of coal.

The ideal fuels for use in pulverized form are undoubtedly those of the higher calorific and volatile content and those low in ash. Nevertheless the only question involved in burning pulverized fuel is the price of the fuel. Anything can be burned that has any heat value regardless of the quantity of volatile matter, sulphur, ash, etc. Mine waste is now beginning to be reclaimed and used. In portions of the country low grade lignites are used.

It is stated that in some modern plants steam generation has actually reached 92 to 94 per cent efficiency on short tests, and 90 per cent continuous efficiency. The average plant is probably under 55 per cent efficiency. The average overall thermal efficiency of a hand fired steam boiler at about 55 per cent, when good coal is used, may sometimes be increased to 75 per cent with best conditions and a particularly skillful fireman. Efficiencies of 40 per cent and even less are often recorded on tests. An average of 55 per cent is therefore good normal practice for hand firing.

Modern mechanical stokers, however, give very good reliable results over long periods of operation at or about their rated capacities. The rate of fuel burned per hour cannot be much increased especially where low grade high ash fuel is used.

The class of fuel that can be burned on a mechanical stoker is, to a large extent, limited by the design and adjustment of the stoker.

The average thermal efficiencies on chain grate stokers burning high ash low grade coal is from 55 to 75 per cent.

In November, 1925, we put into operation in connection with one of our boilers at the 21st Street Pumping Station in the City of Des Moines a unit pulverizer which was designed and built by our Chief Mechanical Engineer, George A. Conrath, a member of this Asso-

ciation, who was formerly with the Bethelehem Steel Company at the Cambria Plant, where he had considerable experience with pulverized fuel. This machine differs in many respects from any other that we know.

The pulverizer has an automatic feeding device which is belt driven from the main shaft of the unit. This shaft is 3½ inches in diameter with six sets of ordinary low carbon steel rotors. There are six impact hammers on each rotor. The impact hammers are made from tool steel and heat treated to make them very hard. The casing is made in two pieces, from cast iron, an upper and lower half. There are two compartments, one for the pulverizer, the other, somewhat larger in diameter, for the fan. The cast iron casing is lined with corrugated chrome steel liners. Between each rotor reacting or retarding blades are fastened on the inner liner. The fan is fastened on the same shaft as the impact hammers, thus making the mill a complete unit. The casing is fastened on a bed-plate which is large enough to accomodate a forty horsepower motor which is directly connected to the shaft of the pulverizer.

The coal is burned as received from the mines without being dried. Although not essential, we think better results can possibly be obtained by drying the coal to a moisture content of from one to five per cent. Dry coal is easier to pulverize and burns more effectively.

A belt type magnetic separator is used for the removal of tramp iron from the coal. As a further precaution in the first stage of the pulverizer there is a tramp iron pocket. The rotor in this compartment is made smaller to give it more clearance so that any tramp iron entering the machine will be driven down into the tramp iron pocket. Tramp iron can then be removed at will, thus not causing any interference with the pulverizer.

About 25 per cent of the air for combustion which is used in the furnace is preheated and admitted with the coal at the feeder. The air which enters the pulverizer casing and the pulverized coal which passes along with it cannot pass directly through the pulverizer casing, but must take an irregular course through it. This is due to the fact that there are no openings provided in the rotors and the slots in the adjacent stationary blade members are arranged in staggered relation. Thus some of the air entering the first compartment passes upwardly around the rotor, through the slots in the lining separating the first and second compartment, down along the rotor and through

the opening in the first stationary blade member. The air passing into the second compartment, in order to pass on to the third, must take a lateral zigzag course through the slots of the second stationary blade member or a vertical zigzag course over the second rotor through the second stationary blade opening. In this manner the air is given a drubbing or scrubbing which insures, by the time it reaches the fan, a thorough admixture of air and pulverized fuel. Any coarser particles, which may tend to pass alone with the air are retarded by the impact hammers and stationary blading, thus being left behind for further impact to reduce them to the desired pulverized form.

The boilers consist of four 323 h.p. Springfield Cross Drum Water Tube Type with a heating surface of 3230 square feet, a superheating surface of 700 square feet and a total heating surface of 3930 square feet.

The front wall, back wall and bottom of the furnace are hollow. The furnace contains 2310 cubic feet, which is a volume per rated boiler horsepower of 7.15.

The baffles are of the three pass type with a horizontal baffle on top of the second row of tubes from the rear connecting to the front baffle.

The burner is of the jet type having fan shaped stationary blades for the purpose of throwing a flame of circular or cyclonic effect.

We have made tests from time to time under various operating conditions and on May 13, 1926, an eight hour test was made by our men. The coal was weighed and measurements of the water were taken with a V-Notch meter. This test showed an average boiler efficiency of 81.05 per cent. 6.18 pounds of water were evaporated per pound of coal consumed as fired. The undried coal was fed from the bunker to the pulverizer.

An additional economy is effected during banked boiler hours due to the fact that banking conditions when operating with pulverized fuel are different from those attained in stoker practice. By stopping the fuel and closing the dampers and auxiliary air inlets the boiler is made similar to a thermos bottle and steam pressure can be held up for several hours. The furnace brickwork having been heated to incandescence during operation gives off a radiant heat which is almost all absorbed by the boiler rather than escaping up the stack. The boiler has actually stood many times for a period of from 12 to 14 hours and then been put back on the line in from 5 to 8 minutes.

When it has been off the line also for a long period and become absolutely cold it has been put back into service in 20 minutes.

The coal found in Iowa is one of the lowest grades in the United States. The average B.t.u. per pound of 361 samples as analyzed in our laboratory in 1925 was "as fired" 7998. Three hundred and forty-nine of these samples were Iowa coal, 10 samples were from Franklin County, Illinois and 2 samples were mixed Iowa and Illinois coal. On the "as fired" basis the above coal had an average ash content of 19.02 per cent, moisture 21.13 per cent and sulphur 4.58 per cent. Under stoker operation the average per cent of combustible in the ash residue for the year 1925 was 10.23 and the per cent of combustible matter in the refuse material at the base of the stack was 14.40. Compared to this the per cent of combustible in the ash under pulverized fuel operation was 0.6.

We are so thoroughly convinced of the manifest advantages and savings that are being obtained that we have built and are now installing a second unit and, as soon as expert tests are made verifying our expectations, it is our intention to remove the present stokers and convert the plant entirely to the use of pulverized fuel. This second unit is driven by a steam turbine and the exhaust steam from this turbine is to be used in drying the coal.

This method of firing steam boilers has been in use long enough so that there is an enormous amount of available data on the subject of such a favorable nature that there is little of argument left against it. It is our belief that, when the economies and advantages are known, hand firing and stoker operation will, to a great extent, be replaced by this system, because they are a more wasteful method of burning coal. Pulverized fuel is a further step in a policy of efficiency and economy in the conduct of our business and we predict that in a very short time it will be extensively adopted in water plants because of its many advantages which can be so conclusively demonstrated.

For information on the subject of pulverized fuel your attention is directed to the following authors:

(1) Goodrich: Pulverized Fuel. Charles Griffin & Co., Limited, London; J. B. Lippincott Company, Philadelphia, 1924.

(2) Herington, C. F.: Powdered Coal as a Fuel. D. Van Nostrand Co., 1920.

(3) Haslam and Russell: Fuels and Their Combustion. McGraw Hill Book Co., 1926.

(4) BLIZZARD: Preparation, Transportation and Combustion of Powdered Coal. Can. Mines Branch, Bull 564 (1921), and U. S. Bur. Mines, Bull. 217 (1923).
(5) HARVEY: Pulverized Coal Systems in America. Fuel Research Board, Special Rept. 1 (1919). See also HARVEY: Pulverized Coal. Benn Brothers (1924).
(6) COLE: Power, 59, 900, 940, 955, 1022 (1924).
(7) Review of Cleveland Powdered-Coal Symposium. Power, 61, 158 (1925).
(8) COUTANT: Mech. Eng., 47, 183 (1925). Cf. also reference 4.
(9) KREISINGER AND OTHERS: Tests of a Powdered Coal Plant. U. S. Bur. Mines, Tech. Paper 316 (1923). An Investigation of Powdered Coal as a Fuel for Power Plant Boilers. U. S. Bur. Mines, Bull. 223 (1923).
(10) KANOWITZ: Chem. Met. Eng., 37, 199 (1925).
(11) H. S. B. W. Cochrane Corporation: Finding and Stopping Waste in Modern Boiler Rooms (1921).
(12) TAYLOR, H. S.: Fuel Production and Utilization. D. Van Nostrand Co. (1920).
(13) KREISINGER (in discussion of Hobbs and Heller): Proc. Eng. Soc. Western Pa., 39, 247 (1923).
(14) COUTANT: Power, 61 (January 13, 1925). See also article in Blast Furnace Steel Plant, 13, 156 (1925).
(15) KREISINGER: Mech. Eng., 47, 19 (1925).
(16) KREISINGER AND BLIZZARD: Ind. Eng. Chem., 15, 249 (1923).
(17) ANDERSON: Mech. Eng., 47, 228 (1925).
(18) NEWELL AND PALM: Mech. Eng. (November, 1924).

PROGRESS REPORT ON RECENT DEVELOPMENTS IN THE FIELD OF INDUSTRIAL WASTES IN RELATION TO WATER SUPPLY[1]

COMMITTEE NO. 6 ON INDUSTRIAL WASTES IN RELATION TO WATER SUPPLY

PREVIOUS PROGRESS REPORTS OF THIS COMMITTEE

This Committee has made three progress reports, as follows:

1. "Pollution of Water Supplies by Industrial Wastes," published with some changes and additions in the JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION for May, 1923 (Vol. X, p. 415),
2. "Agencies for the Control of Pollution by Industrial Wastes," published in the JOURNAL for May, 1924 (Vol. XI, p. 628); discussion published in the JOURNAL for December, 1924 (Vol. XII, p. 410),
3. "The Melcroft Coal Company Case," published in the JOURNAL for May, 1925 (Vol. XIII, p. 675).

An abstract of these reports was prepared for the Manual of American Water Works Practice and published in Chapter III (p. 85).

SCOPE OF PRESENT REPORT

Acting under the instructions of the Council on Standardization, the work of this Committee during the past year has been confined to keeping in touch with developments along the lines already reported upon. The problems resulting from the effect of industrial wastes upon water supply for boiler uses, come within the scope of the work of Committee No. 19, of which S. T. Powell is Chairman. V. Bernard Siems, chairman of a subcommittee, has been in communication with the Chairman of this Committee, in order that there may be no duplication of effort.

[1] Presented before the Buffalo Convention, June 11, 1926. Prepared under the direction of the Standardization Council.

COÖPERATION WITH COMMITTEES OF OTHER SOCIETIES

There are two committees of other societies which have to do with problems resulting from the pollution of waters by industrial wastes; namely, American Public Health Association Committee on Waterways Sanitation, of which C. M. Baker is Chairman, and Conference of State Sanitary Engineers Committee on Conservation of Streams, of which W. L. Stevenson is Chairman. Steps have been taken to coördinate the work of these committees and our Committee on Industrial Wastes in Relation to Water Supply.

MAGNITUDE OF PROBLEM

The report of our Committee in 1922, presented information showing 248 water supplies in 24 states of the United States and one province of Canada, which had been affected by industrial wastes of about twenty different kinds. Information obtained by the Committee since that time shows a considerable number of additional water supplies which have been polluted by industrial wastes. Many papers relating to the pollution of water supplies by industrial wastes have been published in the JOURNAL of this Association and other periodicals. The problem is one of increasing magnitude and importance.

The wastes which are causing the most serious and most extensive trouble in water supplies are acid drainage from coal mines and the so-called phenol wastes from gas and by-product coke manufacturing. R. D. Leitch, Associate Chemical Engineer of the Bureau of Mines, United States Department of Commerce, has made two reports recently, one on "Stream Pollution by Wastes from By-Product Coke Ovens" and one on "Stream Pollution by Acid Mine Drainage."

EXTRACTS FROM REPORT OF BUREAU OF MINES, ON STREAM POLLUTION BY ACID MINE DRAINAGE

The following extracts have been taken from the Report on Stream Pollution by Acid Mine Drainage, by R. D. Leitch, Associate Chemical Engineer of the Bureau of Mines, United States Department of Commerce (Serial No. 2725, January, 1926).

According to data gathered by the U. S. Geological Survey in 1920, there were 2397 mines in operation in Pennsylvania, 802 in Ohio, and 1318 in West Virginia, exclusive of wagon mines. The coal produced from these mines

aggregate nearly 221,000,000 tons, Pennsylvania producing more than 116,000,000 tons. The secretary of the Pennsylvania State Department of Mines states that 54 representative mines in the anthracite region average 16 tons of water removed as drainage per ton of coal mined, and 75 bituminous mines average 36 tons of water per ton of coal. The figure for bituminous mines seems abnormally high, 5 or 6 tons of water per ton of coal would probably be nearer the average for the bituminous mines of this State. Examination of a great number of analyses of mine waters in Pennsylvania indicates that an estimate of 200 grains of sulphuric acid per gallon may be assumed. Therefore it would appear that upwards of 9,000,000 tons of sulphuric acid is being dumped annually into the streams of Pennsylvania alone. Drainage from the other States on the Ohio River watershed would double this figure.

Evidence in the case of the Mountain Water Supply Co., Dunbar Water Supply Co., and the Pennsylvania Railroad versus about 30 operating coal companies in the Indian Creek basin in Pennsylvania, shows that for each acre of coal mined, somewhat more than an acre of surface becomes disturbed and subject to increased penetration by surface waters. Except from shallow workings, mine drainage flows are said to be quite constant and vary little with the rainfall, whereas the flow in streams varies considerably from time to time. Figures indicate that approximately 27 per cent of the annual rainfall percolates through the soil and is pumped out as acid water, the maximum and minimum differing only about 17 per cent from the average. Of more than 300 mines examined in Pennsylvania, only 4 mines showed water which was not acid.

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A few mines have installed some sort of equipment in which the free acid is neutralized by contact with limestone, lime, or marl. As a rule this equipment consists of large boxes which are partly filled with the neutralizing agent and have vertical baffles alternately joining at the top and bottom of the box so as to give the water an undulating motion as it flows slowly through the box. A filter bed of coke, cinders, or similar material is provided at the outlet, and the effluent is free from acid and, generally speaking, unobjectionable. More elaborate systems have been installed on the same principle, excepting that settling basins have been provided in which most of the solids in the water are removed.

At one mine iron oxide is recovered and sold for use in gas purification and in the manufacture of certain kinds of paints. During the World War the price of iron oxide was sufficiently high to guarantee a fair return on the process, while providing the company with a source of supply of good water used in coke quenching at the mine. It is believed that this is the only instance where any attempt is being made at present to recover salable by-products from mine drainage waters, and while the company states that the sale by no means pays for the cost of operation, it is more than others have attempted. Drainage from this mine comes from three boreholes and thus is rather easily collected for treatment, but at any other point where the drainage could be collected it might be handled in a similar manner. The use of iron oxide for gas purification and in the manufacture of certain paints is standard practice, and while the market could probably not absorb an unlimited amount of this

material, the method works successfully and offers possibilities to a number of other mines.

Barium chloride or barium hydrate has been suggested as a precipitating agent, and has been used to some extent where local conditions permitted, but so far the cost is prohibitive. J. W. Ledoux has suggested a scheme whereby the barium sulphate precipitated is recovered and sold as blanc fixe and indicates a profit from the process. Blanc fixe is used in fairly large quantities in different processes in America, but it would seem that a general use of barium compounds for neutralizing the enormous quantities of acid mine waters would create such a demand for them that the cost of raw materials would soar to unprecedented height, and the resultant production of blanc fixe would be far more than could be utilized, so that present market prices for this material would drop to almost nothing. However, it is worthy of mention and consideration.

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At first thought it would appear to be fairly simple to treat mine water by some method of neutralization, but in addition to overcoming the difficulty of first collecting the water for treatment, it must be remembered that neutralizing processes generally require large treating and settling tanks, and usually concentrators, evaporators and filters. When we begin to estimate the enormous quantities of water it would be necessary to handle daily, the problem assumes almost impossible proportions. In addition immense quantities of chemicals, chiefly limestone, would have to be employed, and while these are fairly cheap at present and might always remain so, yet the aggregate cost runs into large figures. Assuming the average figures as previously stated for Pennsylvania alone, it is estimated that with neutralization with lime the cost of chemicals would exceed $225,000 per year. Lime is here mentioned as being even cheaper than limestone for general use, on account of the large amount of inert materials necessary to be handled with limestone, although of course limestone is cheaper weight for weight. As such neutralization would make a very hard water, in most cases unfit for industrial use without softening, the additional cost for softening purposes would be about $750,000 annually. It is difficult to arrive at any significant figures for original cost of installation, upkeep and operation, because no data are available, but installation alone would certainly be not less than $10,000,000 even if duplicate sets need not be built to take care of drainage difficult to collect at one central place. It is conceivable that the increased demand for lime and soda ash would result in a considerably higher price than is quoted at present, in which case the annual cost for chemicals alone is problematical.

G. S. Rice has suggested that the use of limestone for rock-dusting to prevent coal-dust explosions will also have considerable effect in neutralizing acid waters within the mine, and this seems to be a very logical conclusion.

Neutralization of acid mine waters will require an expenditure of large sums of money, but it does not seem to be prohibitive in most cases to treat these wastes to overcome in a large measure present objections to their entrance into streams. Whether this will be an economically sound policy or not will depend upon the collection of more definite data than is available at present. Other than satisfying aesthetic demands, there is no reason for spending

more money and effort annually to purify natural waters than the damage amounts to in money and difficulties experienced by users of waters so polluted. The question is, or should be, to decide how much pure waters are worth from all possible viewpoints, and then determine the cost of purification in the same manner. If the one is cheaper than the other, common sense will demand the more favorable.

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Good judgment will have to be used in not burdening industries within one State with large expenditures for purification until other States have established similar regulations, as otherwise, in keen competition with others in industrial markets, the first would be unfairly hampered. While the problem seems to be one for the individual States to solve, no real results may be expected until all affected are working in unison along the same lines and under similar regulations.

A bibliography on the subject, including references cited, is appended to the report.

STATUS OF THE MELCROFT COAL CASE

In 1920 the Mountain Water Supply Company of Pennsylvania, a subsidiary of the Pennsylvania Railroad, filed a bill in equity against the Melcroft Coal Company and some twenty other coal companies, to restrain them from permitting mine water to flow into Indian Creek or its tributaries. This case was outlined in the progress report of this Committee, published in the JOURNAL for May, 1923 (Vol. X, p. 415). The contentions of the plaintiffs and defendants are summarized in a paper by F. Herbert Snow, published in the JOURNAL for September, 1923 (Vol. X, p. 838). A fairly complete summary of the case up to that time was given in the progress report of this Committee, published in the JOURNAL for May, 1925 (Vol. XIII, p. 675). In the JOURNAL for February, 1926 (Vol. XV, p. 142) is published a paper on "Progress of the Melcroft Case" by C. A. Emerson, Jr., of this Committee, presented before the Central States Section meeting, October 9, 1925. Through the courtesy of William B. McCaleb, General Superintendent of Water Companies, of the Pennsylvania Railroad, Mr. Emerson has been enabled to bring the information on this important case up to date.

In conformity with the opinion of the Pennsylvania Supreme Court, an order was issued by the Fayette County Court on January 29, 1925, giving the coal companies until July 30, 1925, to cease discharge of mine drainage into the stream.

On July 27, 1925, four of the principal defendants, viz.: Sagamore Coal

Company, Melcroft Coal Company, Indian Creek Coal and Coke Company and Romney Coal Mining Company filed a petition in the Fayette County Court, setting forth a plan for disposing of the mine waters from their respective mines, and asking for an extension of time. Judge Van Swearingen ordered the petition filed and granted a rule on the plaintiffs to show cause why the plan set forth in the petition should not be approved, and fixed Monday, August 10, 1925, as the time for hearing thereon, and pending said hearing, the enforcement of the decree against these four defendants was staid.

After hearing an argument on the petition of the four defendants, Judge Van Swearingen, on August 10, 1925, discharged the rule made on July 27, 1925, which left the defendant coal mining companies in contempt of court.

Shortly after July 29, 1925, the Attorney General's Department made an inspection of all the mines of the defendant coal companies to see if they were following out the decree of the court issued on January 29, 1925, prohibiting the discharge of mine drainage into Indian Creek after six months, and as a result of this inspection, on September 16, the Commonwealth of Pennsylvania, represented by George E. Alter, Esq., Special Counsel, filed a petition in the Court of Common Pleas of Fayette County, averring that the defendants had not observed and obeyed the decree of the court with regard to the stoppage of mine water into Indian Creek, praying that the said defendants be held in contempt. The Mountain Water Supply Company, et al., filed petitions to join with the Commonwealth in the contempt proceedings, which petitions were granted by the Court. A hearing in these contempt proceedings was held on December 3, 1925, at Uniontown, before Judge Donald P. McPherson of Adams County, who was appointed by the Supreme Court, owing to the death of Judge Van Swearingen. On that date Judge McPherson entered an order making the decree absolute against ten of the defendants. At this hearing the four principal defendants named above agreed to construct a drainage ditch, and court adjourned until March 8, 1926, at which time these four defendants were to report as to the progress made.

A further hearing was held on March 8th and 9th, and Judge McPherson handed down a decree, declaring all the defendant coal companies, excepting the four defendant coal companies named above, in contempt of court, and ordered them "to begin work required for the sealing of their respective mines so as to effectively and permanently prevent the escape of mine water therefrom . . . . and at the expiration of thirty days from . . . . service of copy of the order and decree . . . . if they or any of them shall have failed to effectively and permanently seal their respective mines then . . . . the Sheriff of Fayette County shall proceed to do so."

Further consideration of the rule heretofore granted on the remaining four defendants was continued until June 16, 1926.

It is understood that in compliance with the last order of the Court, some of the coal cumpanies have ceased operating and voluntarily sealed the openings, but others have not as yet done so.

The four principal defendants heretofore named joined together to incorporate a drainage company, the purpose presumably being to collect the drainage in a tunnel and discharge it into the stream below the water company's dam, in accordance with the petition made to the Fayette County Court.

This application was made under the State Corporation Act of April 29, 1874, and the charter was issued by the Governor on February 15, 1926. It is understood, however, that this charter from the State simply permits the Company to carry on business as a commercial corporation, but does not carry any privilege to discharge mine drainage into a stream.

PHENOL WASTES PROBLEM

A general statement of the problem of offensive tastes in water supplies, caused by phenol wastes, was set forth in a report of the Committee on Sanitary Engineering, of the Conference of State and Provincial Health Authorities of North America, at the Thirty-Ninth Annual Meeting at Lansing, Michigan, on June 16, 1924. This report was published in the Proceedings of the Conference, for 1924, and also in the Journal of the American Public Health Association for October, 1924 (Vol. XIV, p. 845).

CHLORO-PHENOL TASTES AND ODORS IN WATER SUPPLIES IN OHIO RIVER CITIES

On January 29, 1926, a memorandum on "Chloro-Phenol Tastes and Odors in Water Supplies in Ohio River Cities" was prepared by Sanitary Engineer, H. W. Streeter of the United States Public Health Service, and through the courtesy of J. K. Hoskins, Sanitary Engineer in Charge of Stream Pollution Investigations, a member of this Committee, this memorandum has been made available. The following extracts have been taken from this memorandum:

In no known instance . . . . has this difficulty (tastes and odors due to phenol wastes) been more persistent or affected larger groups of population than in the area immediately adjoining and tributary to the upper half of the Ohio River, which drains a highly industrialized region serving as a center for the coal, steel and allied industries.

A search for the specific causes of the tastes and odors . . . . revealed the fact that since the war the coke-producing industry has been abandoning the use of the older "bee-hive" ovens for burning coke and has been substituting for them modern by-products plants, from which valuable substances are recovered from the gases, generated in burning the coke, which gases formerly went to waste in the atmosphere. The residues[2] from some of these recovery processes have been found to contain very considerable amounts of tar, phenols, creosotes and similar substances, which, when discharged into sources of water supplies, produce the characteristic "medicinal" tastes and odors in

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[2] These taste-producing substances will hereafter be designated by the single term, "phenols."

them. Although other classes of wastes, notably those derived from producer gas plants, have been found to contain phenols and like taste-producing substances, the relative total amounts of phenols resulting from the operation of by-product coke plants are so much greater than those produced by any other single industry and their production takes place in such concentrated areas, that a large share of the responsibility for the difficulties caused by wastes of this class has logically been attributed to them.

In the upper portion of the Ohio River basin and especially along the Ohio River proper, the situation has been aggravated by the fact that in order to produce bacterially safe effluents for drinking purposes, municipal water purification plants are forced to resort to continuous chlorination of the water in connection with its sedimentation and filtration. This condition is due primarily to the large volumes of untreated sewage which are being discharged into this river system at the present time. The addition of chlorine to water containing small amounts of taste-producing phenols and creosotes has been found to intensify rather than diminish the tastes caused by these substances probably owing to the formation of chloro-phenol and allied compounds, which are known to have exceptional taste-producing properties.

In March, 1924, a report was submitted by Sanitary Engineer H. R. Crohurst of the Public Health Service, giving the results of a survey which he had made of the water supplies affected by tastes of phenol origin and of the industrial plants producing phenol-bearing wastes within the Ohio River basin. In his report, nineteen by-product coke plants were listed as at that time discharging wastes of this character into the Ohio and its tributaries.

In December, 1925, and continuing through January, 1926, tastes of unusually high intensity and long-continued prevalence occurred in the water supply of Cincinnati, which is located at a point on the Ohio River approximately half way between Pittsburgh and its mouth at Cairo, Illinois. About the middle of January letters of inquiry were sent from the Station of Stream Pollution Investigations at Cincinnati to the water works officials of nine cities located along the Ohio River. . . . . In these letters, information was requested bearing on the history of the occurrence of phenol tastes in the water supplies of the various cities up to the present writing; likewise as to the situation resulting in each city from the prevalence of such tastes. On January 28, 1926, replies had been received from all of the cities to which inquiries had been sent and from these replies a fair estimate may be made of the essential factors involved in this situation.

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. . . . five of the nineteen waste-producing plants listed are understood to have installed since 1924 systems for disposing of their phenol-bearing wastes other than by discharging them into the streams. Of these five plants four are understood to be using the 'quenching' system of disposal and the remaining plant, located at Johnstown, to be treating the waste by means of a modified system of broad irrigation . . . . the five plants listed as having installed disposal systems are located at the five points most remote from cities located on the Ohio River proper. Of the remaining fourteen plants understood as now discharging their wastes untreated into the streams, six discharge them directly into the Ohio River.

A study . . . . brings out several facts worthy of emphasis. First, is the decided tendency toward a seasonal variation in the intensity and frequency of occurrence of tastes at each point. In every instance the tastes have been observed more frequently and with greater intensity during the mid-winter months than at other seasons of the year; they have, in fact, been experienced during the summer only at East Liverpool and Steubenville, and in this case only infrequently.

The second point worthy of note is the marked reduction in the frequency and intensity of the tastes between the East Liverpool-Steubenville zone and the Huntington-Ashland zone, which is located approximately 250 miles downstream. A similarly marked reduction is likewise noted as between Portsmouth and the three successive points located below this city.

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The rapid disappearance of the tastes in river stretches subject to no additional pollution can hardly be explained on the ground of added dilution water, as the periods in which the zones of phenol tastes extend farthest downstream are in the winter months, when the volumes of inflowing dilution water are normally highest. The more logical explanation would appear to be, therefore, that the phenols discharged into the river tend to become oxidized by natural agencies possibly similar in their modes of action to those which are concerned in the progressive oxidation of organic matter. There seems to be some basis for this theory in the fact that phenol-bearing wastes have been found to be oxidizable by biological methods of treatment, when a sufficient excess of biological material, such as, for example, domestic sewage, is present to support the reactions which take place. Whatever the true explanation may be, a strong indication exists that some natural purification agency brings about a rapid disappearance of the phenols after their discharge into the Ohio River.

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. . . . the obvious first step in clearing up the situation along the Ohio River proper would be to eliminate the six known sources of phenol waste pollution located directly on this stream. The fact that installation of disposal systems in five coke plants located at points remote from the Ohio River cities has apparently accomplished little if any benefit as far as these cities are concerned would tend to bear out this view.

The replies received from the various Ohio River cities in response to the letters of inquiry sent during the current month have indicated that the phenol tastes occurring during the months of December, 1925, and January, 1926, have been more intense and prolonged in their intensity, have affected longer stretches of the river and have caused more widespread complaints from the public than have any other occurrences of this nature previously experienced.

As far as is shown by these replies, no serious or wide-spread digestive disorders directly attributable to drinking water containing phenols or chlorophenols has been noted, thus far. At Ironton, however, it is stated that in 1925, during the months of September, October, November and December, an outbreak of eighteen cases of typhoid fever, with three deaths, was attributed to the fact that a number of local water consumers had discontinued

drinking the city water because of its disagreeable taste. In several instances, strong public pressure has been exerted on the operators of the municipal filtration plants to suspend chlorination entirely or to reduce the amounts of chlorine added to the water. Thus far, the operators have successfully withstood such pressure as far as the entire suspension of chlorination is concerned, but in a few instances they apparently have reduced the amounts of chlorine to the minimum point consistent with reasonable safety. The possibility of the occurrence of outbreaks of intestinal diseases in these cities as a result of a systematic relaxation in the utilization of this essential factor of safety is ever-present, however, in situations such as have accompanied the prolonged occurrence of phenol tastes during the past two months.

PHENOL WASTES CONFERENCE OF STATES ON THE OHIO RIVER WATERSHED

The formation of an organization of states on the Ohio River watershed, to solve the problems resulting from pollution of water supplies by phenol wastes, was noted in the Progress Report of this Committee, published in the JOURNAL for May, 1924 (Vol. XI, p. 628). In the discussion of the Committee Report, published in the JOURNAL for December, 1924 (Vol. XII, p. 413) E. S. Tisdale, Secretary of the organization, presented a brief report of the conference held at Pittsburgh April 14, 1924. Another conference was held at Pittsburgh February 18, 1926, and Mr. Tisdale has kindly made available to our Committee the minutes of that conference.

This meeting was called to review progress made pursuant to the Interstate Stream Conservation Agreement of Ohio, Pennsylvania and West Virginia, entered into November 17, 1924, and to give particular attention to the status of the disposal of wastes from by-product coke plants. A resolution was passed making Kentucky a party to the interstate agreement. This interstate agreement relates to the protection of water supplies affected by interstate stream pollution. The agreement sets forth a determination on the part of the State Health Departments, "to coöperate in carrying out a policy for the conservation of interstate streams in these states, including the correction and prevention of the undue pollution thereto, to the end that the said streams may be rendered and maintained as suitable sources of public water supplies." . . . . This agreement applies particularly to the Ohio River and its tributaries.

Representatives of the State Health departments of Ohio, Pennsylvania, West Virginia and Kentucky were present at this conference and presented reports on the status of the disposal of phenol-

bearing wastes in their respective states. The facts brought out in these reports are summarized as follows:

Pennsylvania: Six by-product coke plants in Pennsylvania cited. One plant has discontinued operation and been dismantled. Four plants disposing of phenol wastes satisfactorily by closed systems or lagoons. One plant still discharging phenol wastes to Ohio River.

Ohio: Seven by-product coke plants now in operation on Ohio River drainage area. Two other plants building. The companies operating the seven plants have agreed to provide improvements promptly whereby the discharge of objectionable wastes will be entirely eliminated. Three of them are now handling wastes so as to prevent discharge. The companies building two new plants have agreed to make suitable provision to avoid discharge of objectionable wastes.

West Virginia: Six by-product plants cited in West Virginia. Changes are being made in two existing by-product plant disposal methods so that phenol wastes may be kept from the streams. Two new by-product plants are being so constructed that these objectionable phenol wastes will not be discharged to the streams. Two by-product plants are now discharging phenol wastes into the Ohio River.

Kentucky: Two plants in this state. One does not discharge any wastes into Ohio River. One plant discharges phenol wastes directly into the Ohio.

The following resolution was passed:

Whereas The discharge of waste waters from by-product coke plants and other similar industries, containing phenol and other tarry acids causes serious damage to public water supplies obtained at points down stream from such discharge and constitutes a menace to the public health, and

Whereas The natural agencies of self-purification of streams cannot be depended upon fully to protect water supplies from such damage even when such water supplies are remote from the points of discharge.

Therefore Be it Resolved that adequate protection of public water supplies from damage caused by phenol and other tarry acids requires substantially complete and continuous elimination of the discharge of wastes containing such constituents, or substantially complete and continuous removal of such constituents from the wastes by considerable treatment of the same prior to discharge.

It was brought out that the existing laws in all of these four states are adequate to enable the departments of health to enforce remedial measures. The following resolution was passed:

Whereas The discharge of wastes containing phenols and other tarry acids is adversely affecting the water supplies along the Ohio River and its tributaries and is thereby creating a menace to the public health, and

WHEREAS Effective remedies have been provided by a number of industries whereby the discharge of such wastes is eliminated, and

WHEREAS There are a number of plants and works which have not yet taken any steps towards the elimination of such wastes,

Therefore Be it Resolved that the State Department of Health of Ohio, Pennsylvania, West Virginia and Kentucky should promptly institute action to require substantially complete and continuous elimination of the discharge of such wastes or substantially complete and continuous removal of such constituents from such wastes by suitable treatment of the same prior to discharge.

Proposed Federal legislation to control stream pollution was discussed and the following resolution passed:

WHEREAS Proposed legislation is now pending before the Congress of the United States which is intended to provide Federal control of the pollution of streams,

WHEREAS The Interstate Stream Conservation Agreement executed by the Health Departments of Ohio, Pennsylvania and West Virginia has been in effect since November 17, 1924, and has been of value in securing substantial remedial action through coöperation of these states with industry in establishing control and remedies of pollution in the streams of the Ohio River watershed, and

WHEREAS Based upon the encouraging results secured by coöperative state action, this interstate agreement has been extended to include the State of Kentucky to effect betterment of stream pollution in that state, be it

Resolved by the State Health Departments of these coöperating states, to wit; Ohio, Pennsylvania, West Virginia and Kentucky, that Federal legislation with regard to the control of stream pollution is not necessary or advisable at this time.

EXTRACTS FROM BUREAU OF MINES REPORT ON STREAM POLLUTION BY WASTES FROM BY-PRODUCT COKE OVENS

In Public Health Reports, September 25, 1925 (Vol. 40, No. 39, p. 2021) is published a report on "Stream Pollution by Wastes from By-Product Coke Ovens," by R. D. Leitch, Associate Chemical Engineer of the United States Bureau of Mines. This report is in the nature of "A Review with Special Reference to Methods of Disposal" and has a bibliography on the subject, including the references cited. The following extracts are taken from this report.

Sources of pollution. Figures for the volumes of phenol wastes are not easily determined. In 1923, more than 55,000,000 net tons of coke were produced; and of this amount about 37,000,000 tons were from by-product ovens. Some of these plants dispose of the wastes by quenching the coke (70); but if we

assume 250 gallons per ton, which seems a fair estimate, there are more than 38,000,000 tons of still wastes to be disposed of annually. It may be estimated that only 60 to 75 per cent of this total is being run into streams, as some of the largest coke producers are utilizing the wastes for coke quenching. On January 1, 1924, there were 709 ovens under construction, of which 541 were as additions to existing plants and the remainder divided among seven small new plants. These additions will increase coke production in 1924 by about 4,500,000 tons, making the total for 1924 approximately 60,000,000 tons, and the total from by-product ovens about 40,000,000 tons.

Methods of disposal. There are several methods of disposing of phenol wastes at present being utilized, and while not by any means ideal they offer partial solutions of the problem.

The use of these wastes for coke quenching is the most common method of disposal, and, when applicable, is the most certain method, i.e., evaporation.

Recirculation has also been found adequate in various gas works as well as systems of skimmers, settling basins, and filters (40, 72, 73).

The Milwaukee Sewerage Commission has found (45) that phenol wastes may be easily disposed of, at least in amounts not exceeding 2 per cent by volume of the total sewage, by admitting these wastes to municipal sewage, when the activated sludge method of disposal is in operation. Comparatively little work has been done toward determining the maximum percentage that can be taken care of in this manner; but it is thought that a volume of 10 per cent or even more may be satisfactorily handled.

The Bradford Road Gas Works, Manchester, England, as early as 1908–1914 successfully disposed of these wastes, for six years, at least, by using the bacterial filter. An improved design has had apparent success on a laboratory scale, as it ran satisfactorily and continuously for a year and was functioning as well at the end of that time as at the beginning. The method in principle is the same as that in the activated sludge sewage disposal plants, i.e., it consists in the oxidizing action of certain bacteria on organic substances. A filter of peat or other humus material is mixed with coke to prevent packing, activated sludge or manure is added to plant the bacteria, and a mixture of clean water and still wastes, in the proportion of 85 per cent or 90 per cent water and the remainder waste, is allowed to trickle slowly through the filter bed. The phenol bodies are oxidized and 10 to 15 per cent of the clear effluent is discarded and a like amount of fresh still waste is added for make-up to be recirculated. The operation is continuous and is said to be very satisfactory.

A German patent claims, in addition to successful operation a recovery of the contained phenols in salable form. This method consists in passing the still wastes through acid resins obtained in the purification of benzol, agitating the resulting liquor with benzol in a washer containing two-thirds benzol and one-third wastes, by which the phenol dissolves in benzol. The phenol-free waste is then drawn off, caustic soda solution is pumped into the washer, and the mixture again agitated. The phenol soda is formed and drawn off, while the benzol may be used over again. The phenol-soda solution is used in chemical plants in the manufacture of tar paints for rust proofing.

Other processes have been patented, based on reduction by carbon monoxide or sulphur dioxide, with and without the use of catalyzers, and ozonization,

but no evidence is apparent indicating their commercial use. So far as is known the three methods previously outlined are the most feasible, exclusive of coke quenching.

Cost of systems. Since there are no known installations of the types mentioned in commercial operation in this country, we can only make estimates of the costs of the different methods.

When the amount does not exceed 2 per cent of the total and the activated sludge method is used, addition to municipal sewage is, of course, the cheapest method and means only the cost of piping to the nearest sewer.

The bacterial filter is estimated to cost about $15,000 for a capacity of 20,000 gallons of still wastes per day; but doubling the capacity will not double this cost by any means.

In spite of the fact that the cost of disposal by coke-quenching is estimated by the largest by-product coke company in the world to be $60,000 per year for repairs and replacement of equipment destroyed by corrosive gases resulting from this method of disposal, it is still the cheapest method now available per ton of coke produced. Its use may be limited, however, to those plants manufacturing coke for industrial rather than domestic use. In the latter case the appearance of the coke and the odors from it hinder its sale to a very great extent. . . . .

Assuming that the patented methods of ozonization, reduction, etc., are successful, it is likely that their cost would exceed that of any of the others.

There are two general methods involving washing of the liquors with benzol, previously mentioned, and possibly others of the same classification that appear very promising, but no data are at present available to warrant any definite statement as to cost or efficiency in operation.

EXTRACT FROM PAPER ON ELIMINATION AND RECOVERY OF PHENOLS FROM CRUDE AMMONIA LIQUORS, BY ROBERT M. CRAWFORD

A paper on the elimination and recovery of phenols from crude ammonia liquors, by Robert M. Crawford of the McAleenan Corporation of Pittsburgh, was published in the Journal of Industrial and Engineering Chemistry for March, 1926 (Vol. XVIII, p. 313). The following extract has been taken from that paper:

Waste liquors from coke-plant ammonia stills constitute a known source of stream pollution due to the presence of very appreciable quantities of phenol and cresols, which are scrubbed out of the gas by the flushing liquors and which ultimately reach a stream via ammonia still wastes. In the crude ammonia liquor the phenols exist in solution in the "free" state, but when lime is added in the still to decompose the fixed ammonia, most, if not all, of the phenols are "fixed" and pass into the still waste as calcium phenolates. This "fixing" of the phenols probably explains why the phenols are not often found in the free state in the still wastes. However, owing to the absorption of carbon dioxide from the atmosphere adjacent the waters of a stream, or perhaps to mineral acids in the stream, the phenolates are decomposed, liberating

the phenols in free state. The free phenols thus constitute a source of stream pollution. This liberation may take place at a considerable distance down stream from the offending coke plant.

In order to prevent such stream pollution, it has become customary practice in the coke-oven industry to quench the hot coke with ammonia still wastes, which affords a simple and easy means of disposal. This method, however, seems to have certain obvious objections. (1) The phenols are completely vaporized with the water and are dissipated into the atmosphere only to condense and collect on surrounding territory, perhaps to be washed into a stream by natural rainfall; (2) corrosive compounds contained in the still waste, or formed during quenching of hot coke, give rise to rapid deterioration of quenching equipment; (3) a marked discoloration and a disagreeable odor are imparted to the coke, which affect its sale for domestic purposes; (4) if suspended calcium salts exist in the still wastes, clogging of the coke pores results, which prevents the free burning of furnace coke.

In investigating commercial means for the possible recovery of the phenols from the crude liquor, the writer recalled a method used early in the World War for recovering phenol from the waste liquors from synthetic phenol fusions. This method consisted simply in extracting the waste liquors with benzol, which dissolved out the phenol. Dawson[3] describes a similar method used in England for the same purpose. For the recovery of the phenol from the benzol extract, the method suggested by Weiss in 1916 offered the most likely procedure which was to remove the phenol from the benzol extract by means of a solution of caustic soda. These basic methods of procedure offer practical possibilities which have been demonstrated successfully on a commercial scale by the Foundation Oven Corporation's installation for the Hudson Valley Coke & Products Corp., at Troy, N. Y.; and similar installations by the National Tube Company and the Iroquois Gas Corporation. These three installations operate over the same basic principles, and differ only in details of operation.

A description of the system is given, together with approximate amounts of raw materials consumed and products recovered. Patent applications have been filed, covering the essential features of the process.

INFORMATION FROM THE NINETEENTH ANNUAL REPORT ON WATER EXAMINATION—LONDON METROPOLITAN WATER BOARD

The following information has been taken from a review of the report of Sir Alexander Houston, Director of Water Examination for the Metropolitan Water Board of London, for the year ending March 31, 1925, by Melville C. Whipple, Instructor in Sanitary Chemistry, Harvard Engineering School, Cambridge.[4] This report

[3] Jour. Soc. Chem. Ind., Vol. 39, 151T (1920).

[4] Jour. New Eng. Water Works Assoc., Vol. 40, p. 33.

includes an article describing the experiments by B. A. Adams, F.C.S., on chlorinated water containing phenol compounds:

It appears that considerable trouble from the iodoform taste occurred at a plant under Mr. Adam's direction, where well water was softened, chlorinated and allowed to settle in open tanks. The trouble was intermittent in character, being most frequent in October and November and least so in May and June. The affected water sometimes showed an absence of residual chlorine, again a trace.

Investigation proved that the water acquired the taste during times of rainfall, especially if the precipitation followed a long period of good weather. Slow, steady rain, or a warm humid atmosphere, sometimes produced trouble, but the worst conditions were those during a fog, when the water would be "quite unpalatable." The accompanying wind direction was usually, but not always S.W.W., or calm. Other towns lie in every direction, but an industrial city and a large gasworks are located a few miles away to the S.W. Few occurrences of the taste were noted during cold weather, none during fair weather, and only two during daylight.

Taste was never present in water untreated with chlorine compounds, and, what is more remarkable, at no time when the water contained organic coloring matter as a result of surface pollution.

The conclusion reached was that under certain meteorological conditions substances are precipitated from the air into the tanks and that these combine with the added chlorine to form compounds which give distinctive and obnoxious tastes and odors; also that very small quantities of these impurities are potent. Air contamination was experimentally proved by exposure of chlorinated water having no taste. Two days of fog sufficed to precipitate substances into the exposed water, which gave a strong iodoform taste after addition of 0.2 part per million of chlorine in the form of sodium hypochlorite. Agitation and exposure to light dissipated the taste. The substances causing it could be collected in the distillate after the sample was boiled.

The natural inference drawn, as a result of common experience with the chlorination of phenol polluted surface waters, was that phenol-like compounds, thrown into the air by distillation and combustion of coal, were capable of precipitation in such amounts as would produce offending tastes after chlorination. Tests upon distilled water through which air had been aspirated gave doubtful phenol reactions, but distinct iodoform tastes when chlorinated; other tests upon rain water gave a phenol indication to the extent of two parts per million and strong tastes.

. . . .

The summarized results of Adam's work are given as follows:

1. That there is some constituent in the atmosphere at certain times and at certain places, which combines with chlorine added to a water and causes an iodoform taste.

2. That this constituent is probably of a phenoloid character derived from gasworks and from imperfectly burnt coal.

3. That the reaction does not take place if the water contains a trace of free ammonia.

4. Nor does it take place if the chlorinated water is not exposed to air or if the water contains an unusual amount of organic matter.

5. A chlorinated water should not be exposed to air, at least in the proximity of towns or gasworks, nor afterwards be mixed with water which has been so exposed.

The work of Adams was confirmed and extended by Drs. Thresh and Beale, who made a series of taste and odor experiments adding various amounts of phenol to well water and then 0.25 p.p.m. of chlorine. Their experiments with ammonia as a preventive measure gave conflicting results:

Following the publication of Adams's work the Metropolitan Water Laboratories conducted a series of 37 experiments dealing with taste production, prevention and removal. These are given in detail and in summarized form and confirm previous findings of the Laboratories and, in general, those of Adams.

London air, both unfiltered and filtered through cotton, when passed through tap water, added substances which provoked an iodoform taste with certain doses of chlorine, even after dechlorination with SO_2. The latter does not cause taste in water in moderate excess.

London rain water when mixed with tap water in a proportion as low as one per cent caused the development of an iodoform taste when 0.5 part per million of chlorine was added.

Tap water containing as low as one part phenol in 1,000 million parts of water took on the taste after addition of 0.5 part per million of chlorine.

Substances found to be effective in combating the taste produced in the presence of phenol bodies were:

1. Organic matter, present in the water to be treated. This may give rise to other tastes than that described as "iodoform."

2. Chlorine. Super-doses followed by dechlorination with SO_2 gave satisfactory results.

3. Potassium permanganate. Addition before or after chlorination was equally effective. From 0.2 to 1.6 parts per million were necessary.

4. Ammonia, ammonium chloride and ammonium sulphate. These must be added in advance of chlorine to be effective.

PROGRESS IN STREAM POLLUTION CONTROL IN PENNSYLVANIA

Coöperation now appears to be the watchword in a number of states for solving problems resulting from the pollution of waters by industrial wastes. The following information in regard to the method of attacking the problem in Pennsylvania has been furnished by W. L. Stevenson, Chief Engineer of the State Department of Health and Secretary of the Sanitary Water Board.

During the early summer of 1924, preliminary conferences were held between the Sanitary Water Board and its engineers and executives of some of the largest leather tanning companies in Pennsylvania and their engineers and chemists for the purpose of arranging for coöperative investigations of tannery waste disposal.

On July 30, 1924, a formal meeting was held in Harrisburg between the Sanitary Water Board and representatives of most of the Pennsylvania Leather Tanning Companies. This meeting approved a form of agreement between the Board and the industry which was subsequently executed by practically all of the companies operating leather tanneries in Pennsylvania whose wastes are discharged directly to the stream.

The agreement provides for the creation of a fund of $35,000 contributed by the participating companies in proportion to the capacity of their tanneries expressed in pounds of green, salted hides per day. Provision was made for financial participation by the Sanitary Water Board.

The agreement also created a committee consisting of three Chief Engineers and three Chief Chemists of the participating companies and the Chief Engineer of the Sanitary Water Board as Chairman.

In mid-summer 1925, the Sanitary Water Board and its engineers had a meeting with representatives of the larger pulp and paper mills of Pennsylvania, which resulted in the creation of The Pulp and Paper Waste Disposal Committee of Pennsylvania, consisting of engineers and chemists representing that industry and the Chief Engineer of the Sanitary Water Board as Chairman.

The Committee was charged with making a report to the Sanitary Water Board, setting forth the present status of waste disposal in the industry with recommendation as to the best procedure to obtain information concerning the unsolved problems. On December 19, 1925, the Committee submitted its report wherein it recommended that as the problem of pulp and paper mill wastes is practically national in scope, that the investigations of unsolved problems should be carried out on a nation-wide scale. The report included the following resolutions:

Resolved, that the best procedure to obtain information concerning the unsolved problems relating to the disposal of pulp and paper mill wastes for the further improvement of the waters of the State will be studies and investigations of the unsolved problems by the Forest Products Laboratory, United States Department of Agriculture which also will act as a clearing house for the collection of the necessary data and that the expense thereof should be borne by the Pulp and Paper Industry, the Federal Government and interested States and be it

Further Resolved, that it is the intent of these resolutions that each interested State shall have full and complete control of all matters within its own jurisdiction and that the Federal Agencies shall act in an advisory and consulting capacity in the scientific phases of the various problems and also act as a clearing house for the collection of the necessary data, and be it

Further Resolved, that the Waste Committee of the Technical Association of the Pulp and Paper Industry be requested to include in its next annual

report this plan of procedure with a recommendation that it be endorsed by the Technical Association and referred to the American Paper and Pulp Association for approval and appropriate action.

The Committee on Wastes of the Technical Association of the Pulp and Paper Industry included such a recommendation in their report to the Technical Association at its meeting in New York City on February 22nd to 25th, endorsed the resolution and referred it to the American Paper and Pulp Association, then also in session. The latter Association of executives in the industry endorsed the resolution and referred it to their Executive Committee with power to act.

Subsequently, on or about April 1, 1926, and in accordance with the above stated actions, "The National Committee on Stream Pollution for the Pulp and Paper Industry" was created, its personnel consisting of two representatives of the industry from mills each in Michigan, Wisconsin, Ohio and Pennsylvania, one in Massachusetts, one in Maine, the Secretaries of the Technical Association of the Pulp and Paper Industry, and of the American Paper and Pulp Association, and the Chief Engineers of the Departments of Health of Wisconsin, Ohio, Maryland and Pennsylvania.

PROGRESS IN STREAM POLLUTION CONTROL IN OHIO

The following information regarding the progress made in the control of stream pollution in Ohio has been furnished by W. H. Dittoe, formerly Chief Engineer of the State Department of Health and a member of this Committee, and F. H. Waring, the present Chief Engineer. A paper on the activities of the Ohio State Department of Health with reference to stream pollution by C. C. Hommon, Assistant Engineer, was presented before the Fifth Annual Ohio Conference on Water Purification at Akron, Ohio, on October 15, 1925.

On March 4, 1925, an Act was passed by the General Assembly of the State of Ohio which provides, among other things, for the approval of the State Department of Health of any new or increased discharge of industrial wastes, for general supervision by the State Department of Health of the operation and maintenance of industrial wastes treatment plants, and for a general study of the condition of the streams of the state. This study is now nearly completed. The State Department of Health is further authorized to adopt such regulations as may be necessary for preventing undue pollution of streams and for providing proper protection to the public health.

During the year 1925 attempt has been made by the State Department of Health to interest various groups of industry in the problem of disposal of

industrial wastes. Conferences have been held with representatives of the paper industry, beet sugar industry, canning industry, milk industry and steel industry producing acid iron wastes. The attempt has been made to outline the problem of correction of stream pollution and to secure voluntary action by industry in a study of methods in securing the desired results. The effort has met with considerable support on the part of the industries and several committees have been formed for the purpose of carrying out the recommendations.

At a meeting of the Miami Valley Paper Manufacturing Association on April 12th, a committee was appointed to represent the paper manufacturers of this state. This committee expects to coöperate with the Department of Health in dealing with problems of waste disposal from the paper industry; also to disseminate knowledge regarding installation of Save-Alls in manufacturing plants of this character. Thus far two treatment plants are installed at the Chillicothe Company and the Peerless Paper Company of Dayton. Both are reported to be quite successful in correcting pollution conditions.

Conferences with representatives of the canning industry have been held recently which indicate that a fund is being subscribed by means of which the canners expect to employ expert advice on the installation of treatment works at one or two canneries this summer upon the performance of which recommendations will be based for other canneries to be guided by.

On May 7th, at a meeting of representatives of the milk and dairy industry a committee report was presented recommending that the group association and the membership create a fund to employ a sanitary engineer to design works and check the performance of existing installations serving the milk industry. In all probability this engineer will be retained permanently for consulting service.

. . . . One meeting has been held with the chairman of the manufacturers committee on acid iron wastes disposal and another will be held shortly. One plant has determined to employ engineering service and construct a waste treatment works to eliminate acid and oxidize all iron discharged into the stream.

In addition to the coke plants on the Ohio River drainage area in Ohio, referred to under the caption "Phenol Wastes Conference of States on the Ohio River Watershed," there is also the problem due to coke plants located in the northern part of Ohio on the Lake Erie drainage area. Six plants exist in this area. At Cleveland, plants are operated by the American Steel and Wire Company, the Otis Steel Company, and the McKinney Steel Company. About two years ago each of these companies made corrections to avoid discharge of wastes by using them for quenching of coke. The situation at Cleveland is thus taken care of satisfactorily. At Lorain, the National Tube Company operates a process of recovery of phenol from ammonia still wastes. After removal of the phenol, the still waste is discharged. The final cooler waste, not recirculated, is discharged also the benzol plant waste. Thus the Lorain situation is only partially corrected. At Toledo, the Toledo Furnace Com-

pany discharges all wastes into Maumee Bay. Thus far the Department of Health has not attempted to correct this situation. At Painesville, the Diamond Alkali Works operates a coke plant for the purpose of producing ammonia primarily. The coke plant wastes mingle with the chemical plant wastes which are settled in large artificial ponds, the overflow from which is discharged. Substantial reduction of phenol content is said to be secured.

In general the experience in Ohio has indicated that the most effective method of handling by-product plant wastes, from the standpoint of protecting a water supply, is to use them for the quenching of coke. It appears that the coke companies themselves are generally agreed that this is the best method to use with the knowledge now available. It is worth while observing that all of the accomplishments thus far realized in securing the improved handling of coke plant wastes in Ohio have been brought about without court action and without the issuance of police power orders of the Department of Health. While ample law exists to handle this situation forcibly, effort has been made to deal with the coke companies on a friendly basis and with an attitude of advising or suggesting rather than ordering. The experience thus far has indicated that this is the right way to proceed. While actual accomplishment of improvements in handling coke plant wastes remain to be secured in several of the Ohio Plants, definite promise of plant executives has been given that improvements will be provided in each plant on the Ohio River drainage area by the middle of the coming summer.

PROGRESS OF STREAM POLLUTION CONTROL IN WISCONSIN

The following information in regard to the progress in stream pollution control in Wisconsin was furnished by C. M. Baker, State Sanitary Engineer of the State Board of Health of Wisconsin.

(1) We have coöperated with Pennsylvania, Ohio and other states in inaugurating a national movement for the study of the problem of disposal of paper mill wastes in coöperation with the Forest Products Laboratory of the Federal Department of Agriculture. This coöperative program involves an appropriation by the Industry to be used by the Forest Products Laboratory in solution of the problem of disposal of wastes from the paper industry. Much progress has already been made since many of the paper mills have made material improvements. . . . .

(2) We have made definite arrangements with the Pea Packers Association of Wisconsin who have appropriated five hundred dollars to carry on research work during the coming summer in developing a proper method of treatment for these wastes. This research will be carried on at the Poynette Canning Company, Poynette, Wisconsin.

(3) The disposal of wastes from other industries is being investigated when specific complaint is made to this department. We propose, however, as rapidly as possible to definitely take up the problem of each class of waste disposal and hope in this manner to work out definite and constructive ways of solving these important problems.

A bulletin issued on February 20, 1926 by the Railroad Commission of Wisconsin on the Park Falls case explains in considerable detail the situation in Wisconsin with respect to pollution by pulp and paper mill wastes. The Commission finds that the Flambeau Paper Company by reason of its discharge of wastes into the Flambeau River, has violated the statutes and "impaired riparian and public rights in public waters, among others the right to water stock, the right to draw water for public and domestic uses and the public rights of navigation, including the rights of travel, hunting, fishing, bathing and recreation." In spite of the above findings, the Commission concludes that "no final action in the premises at this time would be just or advisable." On this point, the Commission states as follows:

. . . . The investigation of this matter indicates that with the whole-hearted coöperation of the various industrial plants located on Wisconsin streams, and of the municipalities using such streams as the outlet for sewage, it will be possible to discover and adopt methods of operation which will reduce the pollution of streams to minimum proportions without burdening the industries and municipalities with unreasonable expense.

The evidence indicates no economically practical method of preventing objectionable pollution from sulphite mills, although experiments are now in progress which promise a satisfactory solution of the problem. Further research will be necessary on the part of the industry, possibly in coöperation with the federal and state agencies, before the problem can be completely and satisfactorily solved. The responsibility for a final and satisfactory solution, however, is primarily that of the industry. On the other hand both the state and federal governments have vital interests at stake, and correspondingly grave responsibilities, which ought to be met by fair coöperation on their part with the industry.

It is Therefore Recommended, That the pulp and paper industry organize the various units of the industry for the purpose of inaugurating and maintaining a sustained, systematic, and scientific search for the solution of the problem of the disposal of the waste materials from the pulp and paper mills, in coöperation with such state and federal agencies as may be available.

. . . . The Commission reserves jurisdiction in this proceeding to enter an affirmative order, such jurisdiction being retained for a period of one year from the date hereof, during which time the Commission will take occasion to observe the effects of the use of waters of the state by industries, to note improvements in methods, and to take cognizance of any remedies that may be applied or attempted by the pulp and paper industry to protect more adequately the public rights in the public waters of the state.

PROGRESS IN STREAM POLLUTION CONTROL IN MICHIGAN

Edward D. Rich, Director of the Bureau of Engineering of the Michigan Department of Health, has furnished the following information:

During the early part of 1925 the Department of Health was without a chemical engineer due to Mr. Badger's death, and a great deal of unpleasant publicity was given to the fact by one of the larger newspapers of the state. A decided sentiment in favor of eliminating stream pollution was created by these articles which were copied throughout the state, and the legislature saw fit in its session to enact an amendment to the empowering act of the Conservation Department, which greatly strengthened the law insofar as dealing with offenders was concerned. At the same time an act was passed which permitted municipal authorities to issue bonds for sewage disposal plants without a vote of the people, when such municipality was ordered by this department or the court to build a disposal plant. With these two acts and public opinion strongly for a stream clean-up, the Department of Health combined forces with the Department of Conservation and started a campaign which would be general in its scope. First, the municipalities on the various river basins were called in groups to Lansing. The matter was presented to them in a plain, straightforward manner. They were given an opportunity to express their views on the subject and after the conference each municipality called was given an order requiring the preparation of plans looking toward the construction of sewage disposal plants and the removal of all raw sewage from the river. After the municipality conferences, the various industries were called in groups. In most cases, immediately after the conference the group was given sixty days to formulate plans for the removal of their industrial wastes from the lakes and streams. The departments took the attitude that where an industry was connected to the municipal sewerage system, their waste became a problem for the municipality.

The Department has been very much pleased with the attitude taken by both the municipalities and the industries at these conferences. It is understood that many of the municipalities have employed consulting engineers or have ordered their own engineer to prepare the plans which we requested. The six months have not elapsed since the first conference, consequently it cannot be said at the present time just what the response will be. In most cases the industrial group has appointed a committee to investigate its particular problem and organized the industry in such a way that experimental work can be conducted for the benefit of the group and act as a clearing house between the industry and the state departments. Recently the paper industry filed its report through its committee, assuring the Department that each individual mill was studying its problem with the idea of recovery as the major item. The canneries have assessed themselves $0.002 per case based on the 1925 pack, to carry out experimental work on their wastes. The sugar industries are conducting experiments in all of the plants in Michigan so that at the end of the next campaign there will be sufficient data available to arrive at

some decision as to which methods for handling their wastes are best. The tanneries have started experimental work, the results of which will be reported on later. The milk industry has been completely circularized, urging that all milk waste possible be returned and other wastes reduced to a minimum, such procedure to be followed until the contemplated experimental work is completed. Practically all of the woolen, silk and cotton mills have agreed to decolorize or remove their dye wastes which have been a source of complaint from the general public.

PROGRESS IN STREAM POLLUTION CONTROL IN MARYLAND

The following information has been furnished by Abel Wolman, Chief Engineer, State Department of Health of Maryland:

Since the Engineering Bureau first began to function more or less activity has been exercised to prevent future pollution of the waters of the State, and to eliminate or lessen the pollution from establishments already discharging objectionable wastes into water courses. The activities in this connection date back to 1915. Studies have included various types of wastes other than domestic sewage. Among these were the discharges from oil refineries, fertilizer and acid manufacturing works, garbage reduction works, tanneries, creameries, canneries, paper mills, alcohol and chemical manufacturing plants.

The usual procedure of the Department is to investigate the nature of any industry contributing to the pollution of a water course, provided the wastes discharged are either detrimental to health or the cause of a nuisance. After learning the process used at the industry under investigation, chemical analyses are made of the various wastes. Frequently special experiments are conducted to determine some treatment method which will produce a satisfactory effluent. The experimental work frequently extends beyond the laboratory scale so as to use practical plant operating conditions. After a method of treatment has been determined, the type of treatment plant is suggested to the officials of the industry who are urged to proceed with its establishment along the lines suggested. After the details of the actual plant design have been worked out by the company, plans are submitted to this Bureau and tentative approval of the installation is given, usually with the provision that, if the final waste discharged is not in the proper condition, additional treatment will be required by this Department. During the construction of the treatment plant, periodic inspections are made and consultations held with the officials of the company so that the progress of the work can be followed. Upon the completion of the treatment works, a plant efficiency run is made. After this, further additions or improvements are urged, if necessary, or additional inspections are made to see that the plant is operated regularly and efficiently.

A considerable amount of work is still to be done with the various industries throughout this State. It is desirable to determine a cheap and efficient method of handling canning factory wastes, since these discharges occur through a comparatively short interval in the summer. In line with our educational campaign to induce the canners to furnish the necessary funds for an experimental plant, a meeting has been held with the National Canners Asso-

ciation. The Department has received assurance from them that they will co-operate by some plan to be evolved later.

The Department finds that it is not essential, in many instances, to use the law to obtain the installation of treatment plants, but to secure the coöperation of all the industries thus far investigated. Of recent date, a committee representing the pulp and paper industry of Maryland has been appointed to study the wastes from this industrial type. It is felt that by operating in conjunction with the national committee of the Pulp and Paper Association, much good should be accomplished.

THE DISPOSAL OF INDUSTRIAL WASTES IN ENGLAND

Norman J. Howard, a member of this Committee, has prepared the following abstract of a paper on the "Disposal of Industrial Wastes in England," by J. H. Garner, B.Sc., F.I.C., West Riding of Yorkshire Rivers Board.[5]

In the West Riding there are about 2,000 premises at which liquid trade wastes are produced, and of these rather less than half discharged to streams. As a rule the volume of refuse discharge is vastly greater than manufacturers imagine and it is seldom that one finds means available for accurately measuring the volume. In addition, there are generally wide fluctuations in the rate of discharge during working hours, together with great variations in the character of the liquid. . . . . Failure to make proper use of purification plant is probably one of the reasons for pollution of streams. In many cases control of works is left in the hands of quite unskilled persons, whereas it should be regarded as an integral portion of any manufacturing process. In fact, it has often happened that a closer study of the nature of the resultant waste liquid has assisted materially in the efficient and economical control of the manufacturing process itself. . . . . Numbers of local authorities have drawn up and put into force regulations governing the discharge of trade waste to the sewer, and several have embodied such regulations in private acts. It may, therefore, be interesting to refer to some of these instances, of which there are now more than 30 in the West Riding. The regulations generally fall under three headings:

A. Regulation of flow
B. Preliminary treatment
C. Special charges for treatment.

The question of preliminary treatment of trade refuse has been approached by the various authorities in different ways. Bradford, Bingley and Manchester call upon the manufacturers to sign an agreement. Many authorities, as, for instance Leeds, Keighley, Brighouse and Liversedge, draw up certain condi-

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[5] Presented at meeting of Society of Dyers and Colorists, Buttersfield, England, and reproduced in Surveyor and Municipal and County Engineer, England, October 30, 1925, No. 1763.

tions which must be fulfilled by the manufacturers. Sometimes the surveyor prepares a typical set of plans of preliminary treatment works for the information of the manufacturer, which need not be closely followed, but which can be adapted to the circumstances of any individual case: this course has been adopted at Brighouse, Elland and Ossett. Some authorities require the manufacturer to prepare plans and submit them for approval; this, for example, is the course taken at Bristol, Leeds, Leicester and Pudsey. In other cases the authority has made an agreement with the manufacturers in the district to allow trade wastes to be discharged to the sewers on condition that the manufacturers will subscribe towards the increased capital costs of sewage works necessary, or the increased working expenses of sewage treatment, or both. This, for example, is the bargain entered into at Tadcaster and Mossley, and form the basis of an agreement recently made between the Linthwaite and Golcar sewerage committee and manufacturers in that district.

With regard to special charges these have generally been based upon the volume and character of the liquid discharged. As a rule, although the authorities have reserved the right to demand preliminary treatment, this has not been enforced when special charge has been made, and the manufacturer has been allowed to discharge the refuse in its crude state, unless there was a possibility of nuisance or damage arising. In districts such as Huddersfield, where there is a staple trade, it is possible to agree upon a flat rate per thousand gallons of trade waste discharged. In other districts, assessing a variety of trades, such as Halifax, Brighouse, schedules of charges have been drawn up for the various classes of liquids, the charges varying with the anticipated difficulties of purifying them.

It will thus be apparent that there is a decided lack of uniformity in the treatment of manufacturers throughout the country with reference to the disposal of their waste liquids, and that there is room for improvement both as regards the interests of the manufacturers and from a rivers pollution prevention standpoint.

FEDERAL LEGISLATION

The so-called "Oil Pollution Act of 1924" was abstracted in the discussion of the report of this Committee, published in the JOURNAL for December, 1924 (Vol. XII, p. 38). Attention was called to Section 9, which directs the Secretary of War to investigate the pollution of navigable waters and their tributaries and to report within two years. This report, which is due on or before June 7, 1926, had not been received at the time of this writing.

Several bills were introduced in Congress during the latter part of 1925 and the first part of 1926, and referred to the Committee on Rivers and Harbors. This Committee according to information received from the Clerk of the Committee, decided not to consider any bills or legislation connected with pollution, until the report of the Secretary of War is received, and it was thought unlikely that the subject would be considered by this Congress.

INTERNATIONAL CONFERENCE ON OIL POLLUTION

The Conference of Maritime Nations, on Oil Pollution, provided for by joint resolution of Congress, approved July 1, 1922, mentioned in the progress report of this Committee, published in the JOURNAL for May, 1924 (Vol. XI, p. 643), has been called to meet in Washington on June 8. All of the twelve nations invited, with the exception of Belgium and Greece, have accepted, and will be represented. The nations which accepted the invitation are Denmark, France, Great Britain, Italy, Japan, Holland, Norway, Spain and Sweden. Former Senator Frelinghuysen, will be the head of the United States delegation.

RECENT SYMPOSIUMS ON STREAM POLLUTION CONTROL

The matter of the pollution of waters by industrial wastes has become of such importance in this country that symposiums on the subject have been held by a number of societies since the "Conference on Stream Pollution" at Philadelphia in October, 1923, to which reference was made in the report of this Committee, published in the JOURNAL for May, 1924 (Vol. XI, p. 628).

A symposium on the disposal of industrial wastes was held by the Division of Water, Sewage and Sanitation, of the American Chemical Society at the fall meeting at Cornell University in 1924.

A series of papers on stream pollution and wastes disposal were presented at the meeting of the American Institute of Chemical Engineers in Providence, R. I., June 23 to 26, 1925, and the papers and discussions will be published in the Transactions of that Society.

At the regional meeting of the American Chemical Society at Madison, Wisconsin, May 28–29, 1926, a symposium on the Disposal of Trade Wastes was held, and the papers will presumably be published later, in the Journal of Industrial and Engineering Chemistry.

At the meeting of the National Health Congress at Atlantic City, New Jersey, during the week beginning May 17, 1926, a session on domestic and industrial wastes in relation to water supply, was held under the joint auspices of the Public Health Administration Section and the Public Health Engineering Section of the American Public Health Association and the New Jersey Sanitary Association. At this session the following papers were read and discussed:

"Administrative Problems in the Control of Pollution of Streams," George W. Fuller, Consulting Engineer, New York City.

"Legal Principles Involved in Industrial Wastes Control," John Fertig, Assistant Director Legislative Reference Bureau, Harrisburg, Pa.
"Administrative Solutions to the Problem of Control of Stream Pollution," John E. Monger, M.D., Director of Health, Columbus, Ohio.

These papers on different phases of stream pollution control constitute a valuable contribution to the literature bearing on the solution of this important problem. The scope of this Committee report does not permit of an adequate synopsis of these papers. It is to be hoped that they will be published promptly in the Journal of the American Public Health Association or, if not, in the JOURNAL of this Association, or in some other journal.

Respectfully submitted,
For the Committee on Industrial Wastes in Relation to Water Supply,
ALMON L. FALES, *Chairman.*

Members of the Committee:
A. C. DECKER,
W. H. DITTOE,
C. A. EMERSON,
HARRY B. HOMMON,
J. K. HOSKINS,
NORMAN J. HOWARD,
F. W. MOHLMAN,
JAMES A. NEWLANDS,
C. A. SPENCER,
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EXPERIENCE IN NEW YORK STATE ON RESOLUTION TO DISCONTINUE CROSS CONNECTIONS[1]

By C. A. Holmquist[2]

The New York State Department of Health has always looked with deep concern upon cross connections between potable public water supplies and polluted auxiliary supplies used for industrial purposes or for fire protection. It has consistently recommended to water supply authorities that such cross connections be eliminated, but, until recently, there have been no laws or regulations regarding cross connections.

A very intensive and successful campaign has been carried on by the State Department of Health for the improvement of public water supplies in this State. Since 1906, when the Division of Sanitation was organized, the number of persons served with filtered or treated water has increased from 700,000 to 8,000,000. This remarkable showing has been clearly reflected in the typhoid death rate which had dropped from an average of 23.6 before 1906 to an average of 3.3 per hundred thousand during the past 5 years. In order to accomplish these results, it has been necessary for the municipalities of the State to spend millions of dollars for improving and protecting their water supplies. For example, Buffalo is just completing a filter plant that will cost upwards of $4,000,000. The elimination of cross connections is another step in this program for the improvement of public water supplies.

In 1918, following two serious epidemics of typhoid fever attributed to cross connections, the Department wrote to every municipality in this State provided with a public water supply, calling attention to the dangers that might arise from cross connections and to the numerous epidemics of water-borne disease resulting from infection of public water supplies through such connections. The waterworks authorities were advised that absolute safety to health could be

[1] Presented before the Buffalo Convention, June 10, 1926.

[2] Director, Division of Sanitation, State Department of Health, Albany, N. Y.

accomplished only by complete severance or separation of these supplies. It was pointed out, however, that if complete severance could not be readily accomplished, there should be not more than one cross connection at one mill and no cross connection should be permitted unless it were provided with properly designed double check valves of improved type; installed in suitably constructed chambers; readily accessible for inspection; and regularly and frequently tested by the proper municipal authorities.

Although this matter has been called to the attention of municipalities in this State repeatedly since that time, there have been relatively few instances where complete severance has been accomplished; or where double check valves of improved type have been substituted for single check valves. In fact, only twelve municipalities in New York State, including New York City, prohibit cross connections between public water supplies and other supplies.

In 1924, the Public Health Council of the New York State Department of Health, realizing the importance of this matter from a public health standpoint, requested the Division of Sanitation to make an investigation and exhaustive study of the entire situation. This investigation covered not only the experiences in this State, but also those of other states and Canada, both from a public health standpoint and from that of fire protection.

It was found from this study that since 1903 there have been at least 38 recorded outbreaks of typhoid fever, definitely traced to cross connections between public water supplies and polluted private auxiliary supplies, resulting in thousands of cases and more than 100 deaths. Nine of these outbreaks were in New York State and in two of them there was a total of 257 cases.

The investigation also showed that, although cross connections equipped with double gate valves and double check valves of improved design, with means for testing and placed in accessible manholes, are superior to older types of single and double check valves, reliance cannot be placed upon any known device to prevent back flow through cross connections. Frequent and regular inspection of double check valves tends to reduce, but does not eliminate, the danger from leakage and it is difficult, if not impracticable, to maintain such close supervision. Leakage of check valves which results in polluted water entering the distribution systems of potable water supplies tends to, and often does, defeat the purpose for which very costly expenditures have been incurred in this State, in order to secure public water supplies of safe sanitary quality.

A detailed report containing six appendices, setting forth the results of the investigation and study made by the Division of Sanitation, was presented to the Public Health Council in June, 1925. This report was printed in part in the April, 1926, issue of the American Journal of Public Health under the title of "Public Health Aspects of Cross Connections and Dual Water Supplies." After a long and careful consideration of this whole matter, the Public Health Council on November 12, 1925, adopted the following amendments to Chapter VII of the Sanitary Code. These regulations have the force of law in New York State and apply to the entire state, except New York City.

REGULATION 15-a. *Certain cross-connections between water supplies not permitted.* No officer, board, corporation or other person or group of persons, owning or having the management or control of any potable water supply furnished to any municipality or water district, shall permit after July 1 1926, any physical connection between the distribution system of such supply and that of any other water supply, unless such other water supply is regularly examined as to its quality by those in charge of the potable water supply to which the connection is made and is also found to be potable. This prohibition shall apply to all water distribution systems either inside or outside of any building or buildings.

Provided that, where such physical connections now include two gate valves with indicator posts, two check valves of the Special Factory Mutual Fire Insurance design or equivalent with drip cocks and gauges for testing, all located in a vault of water-tight construction accessible for ready inspection, the date of discontinuance may be extended until July 1, 1928.

REGULATION 15-b. *Permissible arrangements where dual supplies are used.* If a potable water supply is used as an auxillary supply delivered to an elevated tank or to a suction tank, which tank is also supplied with water from a source with which cross-connections are not permitted by regulation 15-a, such tank shall be open to atmospheric pressure and the potable water supply shall be discharged at an elevation above the high water line of the tank.

The enactment of these regulations met with the immediate and hearty approval of waterworks authorities in this State. The Department is also receiving splendid coöperation from manufacturers and insurance interests, especially the representatives of so-called stock insurance companies. Some manufacturers, and one insurance organization, however, seem to feel that double check valves of improved type afford ample protection if frequently inspected and that the expenditures involved in severing cross connections and providing cisterns and elevated tanks for auxiliary supplies

are unnecessary and excessive. In their opinion, tanks of limited capacity as secondary sources of supply would not give adequate fire protection. On the other hand, the fire underwriters seem to feel that for the average plant a 100,000 gallon cistern or a tank of equal capacity located on the ground or elevated, providing four streams of 250 gallons per minute each for 100 minutes or suction for a fire pump discharging 1000 gallons per minute for the same period, will give, in addition to the municipal supply, satisfactory fire protection and result in better protection than obtains in this State at present. Where the primary source of supply for fire protection is from a potable municipal supply, the tanks or cisterns should be filled with this water and should be covered and so constructed as to prevent pollution of the water in such tanks or cisterns. Steel tanks of 100,000 gallon capacity may be installed for from $3500 to $10,000 each, depending upon local conditions and whether the tanks are elevated.

The Division of Sanitation has received many requests from both water supply superintendents and manufacturers for assistance in solving problems of eliminating cross connections. As the result of these requests, a large number of plants have been visited and conferences held. It has been found from these inspections that, in many cases, cross connections may be eliminated at relatively little, and, in some instances, at no cost except for labor. It was found that cross connections in some cases could be eliminated without impairing fire protection or interfering with industrial operations, by extending the mains of the auxiliary supply from a few hundred to a thousand feet. In another instance, water was formerly pumped from a polluted river for industrial purposes and secondary fire protection, and for emergency use a large cistern was kept filled with polluted water. This cistern has been covered and is now kept filled with city water, the fire pumps taking suction from the cistern instead of from the river. The expenditure for covering the cistern and changing the pumping arrangement was the only one involved and was largely offset by additional yard space provided by the alterations.

In some cases, however, it has been found to be more difficult, and expensive to eliminate cross-connections, especially in very large plants having a large number of buildings, covering large areas and requiring an uninterrupted supply of large quantities of water for industrial purposes. Such plants may need two or more cisterns or

tanks of large capacity and more extensive re-arrangement of piping equipment. The proportionate cost of such changes, however, may not be as great as for smaller plants requiring less extensive changes.

It should not be assumed that *all* large plants provided with private auxiliary supplies have cross-connections. One of the largest plants in this State, which pumps nearly 20 million gallons of water per day from a polluted river primarily for industrial purposes and uses city water for drinking purposes, has no cross-connection with the municipal supply. Dependence for fire protection is placed upon the industrial supply and a large elevated tank filled from that supply. Furthermore, unless an industrial plant is located on or near a river, stream, lake or other body of water, it is usually not provided with a private auxiliary supply. This means that only a very small percentage of the industrial plants in this State have cross-connections and are affected by the regulations of the Public Health Council. According to data submitted by the Associated Factory Mutual Fire Insurance Companies, there are at present 223 properties under their jurisdiction in this State that have auxiliary water supplies and cross-connections, of which 90, or 41 per cent, have Special Type Factory Mutual double check valve installations. The Underwriters have not as yet compiled data as to the number of plants involved. In one municipality, where there are about 150 factories, it was found that only 7 plants have auxiliary supplies and in only 3 of these were the cross-connections for fire protection purposes. Moreover, if auxiliary supplies are derived from potable sources under the supervision of the municipal authorities, cross-connections with such supplies are not prohibited.

While the major problem has been the elimination of cross-connections originally installed for fire protection purposes, cross-connections for other uses in a plant are of equal importance and are more difficult to discover owing to the frequent lack of plans of piping layouts and to the fact that many master mechanics feel that, with the intervention of a gate valve in a pipe line, it ceases to be a cross connection. Frequently the necessary information can be obtained only with considerable difficulty and this, we feel, is not due to any intent to deceive or mislead on the part of the plant engineer. We have found cross-connections between public water supplies and auxiliary polluted water supplies, for many purposes, such as, secondary fire protection, emergency industrial use, emergency domestic use, priming pumps, boiler feed make-up, and auxiliary supplies to

elevated tanks. These cross-connections have been provided with all varieties and combinations of valves, from no valve at all to globe valves, gate valves, single checks, ordinary double checks and Special Factory Mutual double check valves.

I would state in conclusion that, judging from the coöperation received from the water supply authorities and generally from the industrial concerns and fire insurance interests, all dangerous cross-connections will be eliminated promptly and completely in accordance with the requirements of the Sanitary Code, and a serious menace to public water supplies will be removed.

It may be of interest to the members of this Association to know that at the recent Conference of the State Sanitary Engineers, held here in Buffalo on June 5 and 7, 1926, the following resolution was formally adopted by the Conference:

WHEREAS, cross connections, auxiliary intakes and by-passes between potable public water supplies and supplies from other sources have been the cause of a large number of outbreaks of typhoid fever or other water borne disease, and

WHEREAS, check valves and other protective devices, or notifying the public in the case of using water from a polluted source through an auxiliary intake or by diverting the flow around an integral part of a purification plant through a by-pass, cannot be depended upon to adequately protect the public from disease,

Be It Resolved, that no physical connections should be permitted between any potable public water supplies either through cross connections, auxiliary intakes or by-passes and other supplies except as follows:

1. With another potable public water supply.
2. With a potable supply which is regularly examined as to its quality by those in charge of the potable public supply to which the connection is made.

This prohibition to apply to all piping systems, either inside or outside of any building or buildings, and be it,

Further Resolved, that definite programs should be inaugurated in each state and each municipality thereof to permanently eliminate all other connections, and be it

Further Resolved, that the Executive Committee of this conference transmit copies of this resolution to the Fire Underwriters Association and related organizations, also the American Water Works Association, New England Water Works Association and other analogous organizations with the request that they coöperate in securing the carrying out of the provisions of this resolution.

It should be noted that this resolution differs from that adopted by the Fire Protective Division of this Association at the Louisville Convention in May, 1925 only in that auxiliary intakes and by-passes are also included in addition to cross connections.

EXPERIMENTAL STUDIES OF WATER PURIFICATION, BY THE UNITED STATES PUBLIC HEALTH SERVICE[1]

A Preliminary Review of Work Completed and in Progress

By H. W. Streeter[2]

During the past twenty months, the United States Public Health Service has been making an experimental study of the efficiency of current water purification processes in relation to the various conditions of raw water pollution, such as are found along many of our sewage-polluted streams which serve as sources of purified municipal water supplies. For the purpose of making this study, the Public Health Service in 1924 constructed a small, but fully equipped, rapid sand filter plant of modern design, which is located on the grounds of the laboratory of Stream Pollution Investigations at Cincinnati, Ohio. The main supply of raw water for the plant is taken from the Ohio River, but facilities have been provided for adding to the river water continuous supplies either of domestic sewage or of clear dilution water in any desired proportions prior to delivering it to the plant, thereby making it possible to vary at will and over a wide range the physical and bacterial character of the raw water.

The primary objective of the experimental study has been to check, under conditions subject to experimental control, the results of a collective survey of a group of 17 municipal filtration plants made in 1923 and 1924, the major purpose of which was to determine the maximum limits of raw water pollution which are consistent with the production, by the average well designed and operated modern plant, of effluents meeting given standards of bacterial quality. A secondary objective, on which experiments have been undertaken recently, has been to evaluate the different factors, subject to control by the plant operator, which influence, directly or indirectly, the cost and efficiency of bacterial removal by water purification processes of various types. The present paper deals only with the experiments concerned with the primary objective of the study.

[1] Presented before the Water Purification Division, Buffalo Convention, June 9, 1926.

[2] Sanitary Engineer, United States Public Health Service, Cincinnati, Ohio.

In conducting the experiments, the plant has been operated as nearly as possible in accordance with the methods which are common to a majority of the full-scale plants, or, in other words, as though it were an average full-scale plant in actual service. To this end, the plant has been operated continuously throughout the entire 24 hours of each working day, and every effort has been made to produce an effluent comparable, from a physical standpoint, with the effluents delivered by the larger municipal plants. Owing to the experimental nature of the work, the laboratory control has been somewhat more intensive than usually is practiced at the municipal plants.

The general method of procedure followed in making the experiments has consisted in dividing the observations into a series of weekly "runs," during each of which the bacterial pollution of the raw water has been varied progressively over a predetermined range, with all other conditions held constant throughout a given "run." It originally was intended to increase, at intervals of every few hours, the bacterial pollution of the raw water until the plant definitely failed to produce an effluent conforming to a certain assumed standard of bacterial quality, noting in each instance the raw water conditions under which the first sign of deterioration below the standard occurred. In practice, this method was attended by numerous difficulties, owing to sudden and unexpected changes occurring in the quality of the raw water during the short intervals in which an effort was made to hold it constant. The procedure finally adopted was similar to that described, except that the character of the raw water has been changed at longer intervals, usually twenty-four hours or more, and the results of the observations have been averaged by twenty-four hour periods, rather than considered individually.

The results of the experiments have indicated, first, that under similar conditions with respect to the density and character of raw water pollution, the efficiency of bacterial purification shown by the experimental plant corresponds very closely to that of full-scale plants of the same type for which data are at hand. A comparison of the experimental results with the averages of those obtained at five Ohio River plants of the same type during a period of one year, has shown, for example, that when the B. coli index of the raw water as delivered to the experimental plant was less than 5000 per 100 cc. (coinciding approximately with the limiting range in the average densities of raw water B. coli at the five Ohio River plants), the mean residual percentages of raw water B. coli observed in the effluents from successive

stages of treatment diverged by less than five per cent from the mean of the corresponding residuals for the five Ohio River plants. Both this and other comparisons have indicated that the results of observations made at the experimental plant may be applied without any material qualification to the conditions of full-scale plants of the same type and degree of elaboration. This indication is considered as being one of basic importance in relation to the conclusions to be drawn from the experimental study.

The results of the study have confirmed both the existence and nature of a relationship previously observed as between the bacterial quality of the raw water, as delivered to the plant, and the resulting quality of the effluents produced at the various successive stages of treatment. This relationship had been found to be governed by an apparently basic law, which may be expressed mathematically by the simple power function equation $E = cR^n$, in which R denotes the bacterial content of the raw water, E the resulting bacterial content of the effluent, and c and n empirical constants which vary with the type of purification process, the kind of bacteria and the number of intermediate stages of treatment between the source of raw water and of the particular effluent considered.

An analysis of these relationships, similar to one which previously has been made of the data obtained from the collective survey of municipal plants, has given a very satisfactory check on the maximum bacterial pollution of the raw water which is consistent with producing effluents of specified bacterial quality. The results of the collective survey have indicated, for example, that the maximum B. coli index of the raw water consistent with the production of chlorinated filter effluents conforming to the revised Treasury Department standard is approximately 5000 per 100 cc. and the corresponding maximum derived from the experimental study has approximated 6000 per 100 cc. Making due allowance for observational errors and other sources of expected divergence in these figures, their mutual agreement may be regarded as being very reasonably close. As regards the production of *unchlorinated* effluents conforming to the revised Treasury Department standard, the survey has indicated the permissible raw water maximum to be approximately 60 B. coli per 100 cc. and the experimental studies, to be 100 per 100 cc. These two figures, likewise, may be considered as being substantially in agreement with each other.

In reference to these figures, it should be emphasized that they

represent merely observational and experimental maxima, respectively, and are not intended as working standards of raw water pollution for administrative purposes. It is believed, however, that after they have been checked by further observations embracing a wider territory and range of conditions than thus far have been covered,[3] these maxima may be made fairly rational bases for the formulation of practical working standards, having reference to average requirements for permissible limits of pollution of raw water supplies. A raw water standard of this kind, if ultimately adopted, probably should fall somewhere between the two limits above given as being consistent, respectively, with the production of chlorinated and of unchlorinated effluents conforming to the revised Treasury Department standard, its position being defined by the proportion of the total bacterial efficiency of chlorination which is to be held in reserve as a working factor of safety.

A further matter of interest connected with the results of the experimental study has been their indication as to the influence exerted on the efficiency of bacterial removal by certain factors, not subject to control by the operator, notably by variations in raw water turbidity and by periodic changes in seasonal conditions. As regards the extent to which the bacterial efficiency is affected by the two factors named, the experimental observations thus far completed have indicated:

1. That the over-all efficiency of bacterial removal, as measured in terms of the 37°C. plate count, is influenced decidedly by both factors, but the corresponding over-all efficiency of removal of organisms of the B. coli group appears to be affected only to a minor, if any, extent by either factor.

2. That the efficiency of removal both of plate-growing bacteria and of B. coli by preliminary coagulation and sedimentation combined is influenced to a measurable extent by variations in raw water turbidity, this effect being virtually offset, however, as regards the removal of B. coli, by the tendency of filtration and chlorination to equalize whatever differences in the efficiency of the preliminary stages of treatment may be caused by these turbidity variations.

3. In general, the over-all efficiency of bacterial removal and, more especially, of B. coli removal, is affected to a considerably greater

[3] The observations of the performance of municipal filtration plants thus far made in these studies have been confined to the territory lying east of Indiana and north of Kentucky.

extent by variations in the density of bacteria in the raw water than by turbidity or seasonal changes. This statement does not apply necessarily, however, to the efficiencies of separate stages of the treatment process, notably to those of filtration and chlorination, which either tend to remain practically constant or show no orderly relationship to changes in any of the three variables named.

The practical significance of these observations lies in their indication that as far as the more important group of bacteria are concerned, namely those of the B. coli group, neither variations in raw water turbidity nor the changes associated with seasonal rotations appear to have any decided influence on the over-all efficiency of bacterial removal. The only separate stage of the purification process which seems, in fact, to be affected in this respect by variations in turbidity, in season, or in the density of raw water bacteria, is that of preliminary coagulation and sedimentation combined, the bacterial efficiency of which is influenced to a measurable degree by variations in raw water turbidity and to an even greater extent by changes in the density of raw water bacteria. With this exception, the efficiency of water purification processes in respect to bacterial removal appears to be a fairly stabilized phenomenon, relatively uninfluenced by any of the major factors which are not subject to control by the plant operator.

In the secondary series of experiments which are in progress at this writing, it is proposed to study the influence exerted on the efficiency of bacterial removal by those factors which can be controlled, at least in part, by the plant operator. In these experiments, it is planned to study more or less separately the various factors associated with each individual stage of treatment, considering, in order, preliminary coagulation, sedimentation, filtration and chlorination. Attention thus far has been confined to coagulation and sedimentation, concerning which three factors have been studied in a preliminary way, namely, the amount of coagulant, the pH of the coagulation and the period of sedimentation. The results obtained from this limited series of observations have indicated that the bacterial efficiency of coagulation and sedimentation is influenced very decidedly by the amount of coagulant added to the water, and to a measurable, though less well marked extent, by the pH of the reaction and by the period of sedimentation, both of these factors being operative, however, only within certain practical limits.

The experiments are not expected, nor are they intended, to intro-

duce any new ideas or methods of a revolutionary character into the field of water purification. They are being made, on the other hand, with the comparatively single-minded objective of determining, as far as may be practicable, the limiting degree of pollution of streams at water works intakes, consistent with the production of purified water supplies which, in accordance with current standards, may be regarded as safe for municipal and household use. Incidentally, however, it is believed that these studies, when completed, may provide some data of value concerning the practical and economical limitations in the bacterial efficiency of current water purification processes and some suggestions as to the possibilities which may exist for increasing their bacterial efficiency through measures which are subject to control by the plant operator. These measures are, to a large extent, well recognized, and some of them, at least, have been studied and applied by numerous operators. As far as is known, however, little or no systematic effort has been made to determine their relative values from an individual series of comparative experiments, made with this single purpose in view. In this connection, due account must be taken of the factors of economy involved in the problem, to which it is planned to devote a considerable amount of attention.

In conclusion, it is a pleasure to record our indebtedness to our Special Consultant, Mr. J. W. Ellms of Cleveland, Ohio, who has given most generously his time, advice and assistance in formulating and carrying out the working program of these studies. Mr. Ellms' long and active experience in both the experimental and the operative phases of water purification has been an invaluable asset to us in this connection.

STUDY OF YEAR ROUND SOIL TEMPERATURES[1]

By Scotland G. Highland[2]

A study of year round soil temperatures from zero to a depth of six feet below the surface of the ground will afford data of universal practical value in the field of water supply.

Accurate knowledge of frost penetration in city streets is readily seen to be of vital importance to a water department in determining the depth to which water mains and service lines should be buried, in order to avoid the damaging action of frost.

YEAR ROUND UNDERSOIL TEMPERATURES

Thermometers for ascertaining the year round temperature of the subsoil at various depths were installed January 1, 1923, at Clarksburg, W. Va., Lat. 39.3 N., Long. 5 hrs. 21 min. W. Six separate thermometers are used, one being required for each foot of depth investigated, and are installed in an abandoned, unpaved roadway representative of traveled street conditions. These instruments consist each of a stout stem graduated and figured thermometer, enclosed in a wooden case, the upper front part of which is cut out, exposing the eleven inch scale, and ranging in depth from 1 to 6 feet. No shelter should be used for the thermometers.

DAILY READINGS TAKEN

The daily readings of these thermometers check surprisingly well with the records of frost penetration in all parts of the city as found by frequent necessary excavations in the streets during and following protracted cold weather. Another severe winter like that experienced in 1917–18 will supply data of lasting worth.

COUNTRY-WIDE FROST PENETRATION RECORDS

The speaker has thought it advisable to include in this study a record of the lowest depth to which frost has penetrated in city

[1] Presented before Buffalo Convention, June 9, 1926.

[2] General manager, Clarksburg Water Board, Clarksburg, West Virginia.

streets, in American and Canadian cities and towns; the current practice relating to the depth at which water-mains and service-lines are laid, and the resulting experience in freezing, based upon accurate data recently obtained by me from responsible water-works officials throughout the United States and Canada, covering experiences and practices of a twenty-five year period ending March, 1926.

FROST AT DEPTH OF TWELVE FEET

Unless carrying water at high velocities, water-pipes throughout the Northern and Northeastern United States and Canada should be laid well below the maximum frost line, which extends in some cases, as will presently be shown, to the astonishingly low depth of 12 feet.

SERVICES AND DEAD ENDS CAUSE TROUBLE

If laid at sufficient depth water pipes will not freeze. It is not in the mains, but in the services that most of the trouble from freezing occurs, due to the laying of services at depths considerably less than the mains. Water-mains in the "Gridiron System" of the distribution lines, having a good circulation, seldom freeze, but dead ends and shallow services in streets and under sidewalks and lawns, often privately laid and maintained, cause trouble.

WATER PURVEYORS RESPONSIBILITY

In order to insure the selection of suitable piping material, and to obtain a sufficient depth of cover, all service lines should be laid from the main in the street to the cellar or basement of the house or building, by the water purveyor. At no other point do the true interest and responsibility of the water utility end.

A CHANCE TO BE OF USE AT LAST

The patrons served ought to entrust to the care of experienced men the selection of service pipe materials best suited to convey, over a long period of years, the particular water supplied, and to accept the judgment of practical water-works men as to the possible depth of frost penetration in city streets and under sidewalks and private lawns. The actual cost of the entire service line from the main to the cellar, or basement, is a proper charge against the property supplied.

This procedure with regard to the laying of services should, at once, put an end to one of the greatest nuisances found in the operation of a water utility, and certainly provide a dependable year round service to the water consumers for which they would feel deeply indebted.

There are other equally important reasons why water-mains and service-lines should be buried at extreme depths which will be discussed presently.

EARTH TEMPERATURE WARNINGS

With respect to the action of frost the character of the soils, generally classified as gravel, sand, clay, loam, marl, peat, and muck, is a factor of importance in determining the economical depth at which water pipes should be laid; yet, as previously shown, soil thermometers installed at a location typical of traveled roadways will give low temperature warnings throughout the confines of a city equipped with these instruments.

Experiences and practices recently described to me by water-works executives in a dozen selected cities follow:

Calgary, Alberta. In the winter of 1916 frost penetrated to a depth of 12 feet in gravel and 8 feet in loam.

Moose Jaw, Saskatchewan. Frost penetration reaches lowest depth under roadways, where the soil is firmly compact. It is less in boulevards and on private property where the soil is looser, and often protected by grass. In these latter places the frost penetration is about 2 feet less than in abutting streets. Frost penetration is greatest in wet clay soils, and 50 per cent less in sandy soils.

Ottawa, Ont. Frost penetrates to depth of 6 feet where there is considerable traffic. Depth of snow important.

Montreal, Que. Frost penetrates 5 feet depending on nature of subsoil.

Leadville, Colo. Frost penetrates to depth of 9 feet. At present (March, 1926) it is down 8 feet and still going deeper. These conditions obtain where the gravel is loose; in clay formation it does not go so deep. Service-pipes in Leadville are laid in a double boxing from the main to the standpipe at the building. When the frost reaches the service-pipe an upright boiler on wheels is employed to turn steam into the curb box which follows the service through the boxing provided to the main, and thaws out the pipe quickly. Early snows that lie in the streets prevent serious freezing trouble.

Davenport, Ia. Frost will penetrate deeper in one street than in another. It penetrates deeper on the south side of an east and west street than on the north side. Water-mains are laid on the north side.

Portland, Me. Much trouble during winters which have little snow.

Omaha, Neb. Depth of frost varies greatly with amount of snow on the ground; whether the street is paved or unpaved; and the amount of moisture in the soil.

Syracuse, N. Y. Clay soils do not freeze as soon as sand and gravel.

New York City. Particular care is taken to secure a good back fill in trenches excavated in loose material, or in rock, both to prevent freezing and unequal settlement. In paved streets there is but little frost penetration, and the freezing of services might occur only where these lie with shallow cover, near the cellar walls. During the winter of 1917–18, the frost under asphalt pavement on concrete reached a depth of $2\frac{1}{2}$ feet and under other pavements $3\frac{1}{2}$ feet.

Glens Falls, N. Y. Where clay or heavy loam is encountered we have freeze-up troubles. Soil conditions generally sandy. Services in rock trenches have never given trouble.

Clarksburg, W. Va. Frost penetration in 1917–18 reached a depth of 3 feet. Mains and services are laid with four feet cover. Lat. 39.3 N. Long. 5 hrs. 21 min. W.

Bluefield, W. Va. Services have frozen under paved streets at depth of $2\frac{1}{2}$ feet.

As a general proposition, it is customary to lay water-pipes no deeper than is necessary to furnish adequate protection against frost action. However, there are other important reasons why pipes should be buried well below the lowest frost line.

IMPACT THE NEW ENEMY

Undoubtedly, heavy motor trucks on rough paving develop impacts and vibrations which tend to displace cast-iron water-lines.

There is frequently leakage from mains and services not laid at sufficient depth on account of vibrations, due to traffic, in certain peculiar soil conditions.

Broken services and blown joints are often caused by impact of heavily laden trucks with unevenly worn solid tires, which administer terrific blows to the surface over which they travel at high speed. Impact is the new destructive enemy of pavements and underground water lines. When a loaded motor truck, weighing,

with its load, 22,500 pounds, and moving at a rate of 15 miles an hour, encounters an obstacle on the highway sufficient to give the wheels a drop of 1 inch, the effect upon the road is practically the same as though the total weight was multiplied several times. In a sense the truck becomes a projectile and batters the surface with mighty impacts, causing trouble to all underground piping. Smaller trucks act in a similar way, but with an impact or striking force in proportion to the weight, load, condition of tires, and obstacles encountered on the highway.

CONTRACTION AND EXPANSION

At lower depths the ground temperature becomes more uniform and a difference of 1 or 2 feet is appreciable in contraction and expansion of the pipes, and measurable in the water temperatures.

MINIMIZES ELECTROLYTIC ACTION

The deeper pipes are laid the less susceptible they are to electrolysis, but the speaker regrets that he has no authentic data to determine the magnitude of this difference.

PREVENTS DAMAGE TO PIPES

It is undoubtedly true that if water pipes are laid at a minimum depth of 5 feet they will be below the depth at which other utilities, aside from sewers, explore in search of their subsurface equipment, often to the detriment of water-mains and lead services.

FREER FROM IMPURITIES

The soil at lower depths is ordinarily freer from impurities affecting the life of the pipe, especially where there has been a filling with cinders or other materials having a tendency to corrode the pipe.

HIGHEST AND LOWEST SOIL TEMPERATURES

An accurate record of the highest and lowest soil temperatures and air temperatures at Clarksburg, W. Va., from January 1, 1923, to April 30, 1926, is shown in table 1. Table 2 gives a record of current practices in laying pipe, with reference to penetration of frost.

TABLE 1

Highest and lowest soil temperatures, Clarksburg, West Virginia

MONTH		SOIL TEMPERATURES						AIR TEMPERATURES		
		12"	24"	36"	48"	60"	72"	Maximum	Minimum	Mean
For the year 1923										
January	H	41	40	40	44			58		
	L	37	38	39	42				7	35
February	H	45	43	42	43			62		
	L	32	35	36	40				0	29
March	H	45	43	42	43			76		
	L	34	35	36	39				12	41
April	H	54	52	50	50	50	48	82		
	L	37	40	40	43	44	46		7	50
May	H	65	62	57	56	54	54	89		
	L	50	52	50	50	50	49		32	61
June	H	72	68	66	64	58	56	97		
	L	62	62	58	56	54	54		44	72
July	H	72	70	67	66	64	62	91		
	L	66	66	63	63	64	61		48	72
August	H	74	72	69	68	66	64	90		
	L	66	66	65	66	64	62		44	72
September	H	70	69	66	66	65	64	90		
	L	60	62	62	63	63	62		40	67
October	H	64	65	63	64	63	62	84		
	L	48	52	52	55	56	56		28	52
November	H	50	52	52	56	56	57	67		
	L	41	42	43	47	48	50		20	43
December	H	49	48	46	48	50	52	69		
	L	40	42	42	46	48	48		14	45
For year	H	74	72	69	68	66	64	97		
	L	32	35	36	39	44	46		0	53
For the year 1924										
January	H	46	45	43	46	48	48	70		
	L	33	34	36	40	42	44		−3	34
February	H	37	38	36	40	41	43	70		
	L	34	34	34	36	40	42		9	33
March	H	45	43	40	42	42	42	80		
	L	34	34	34	38	40	41		16	42
April	H	52	50	47	48	48	47	79		
	L	39	40	40	42	42	42		21	52
May	H	58	56	52	53	52	52	87		
	L	49	50	48	48	48	47		34	58

TABLE 1—*Continued*

MONTH		SOIL TEMPERATURES						AIR TEMPERATURES		
		12"	24"	36"	48"	60"	72"	Maximum	Minimum	Mean
For the year 1924—Continued										
June	H	69	68	64	62	60	58	92		
	L	55	55	53	54	54	52		42	71
July	H	70	68	65	64	63	61	94		
	L	66	66	63	62	60	58		47	72
August	H	70	70	67	66	64	63	96		
	L	66	67	65	64	63	61		49	74
September	H	70	69	68	66	65	64	92		
	L	60	62	61	62	62	62		38	64
October	H	61	62	61	62	61	61	82		
	L	50	52	51	55	57	57		25	56
November	H	51	52	58	57	58	57	76		
	L	41	42	45	50	51	52		13	43
December	H	48	44	44	50	51	52	70		
	L	35	38	39	43	46	48		1	35
For year	H	70	70	68	66	65	64	96		
	L	33	34	34	36	40	41		−3	50
For the year 1925										
January	H	37	39	39	44	46	48	56		
	L	34	36	37	37	42	42		−8	30
February	H	43	42	40	42	42	44	71		
	L	36	36	36	39	40	42		6	38
March	H	48	46	44	45	45	45	78		
	L	36	37	37	40	42	43		3	44
April	H	59	57	53	52	51	50	95		
	L	42	42	42	44	44	45		27	52
May	H	60	60	56	56	55	54	89		
	L	50	52	50	52	51	50		31	57
June	H	70	68	65	64	62	60	100		
	L	61	59	56	56	55	54		47	73
July	H	74	72	68	67	65	64	98		
	L	68	67	64	64	62	60		46	74
August	H	71	70	67	67	66	65	96		
	L	66	66	66	66	64	63		46	72
September	H	71	70	65	68	67	64	101		
	L	65	66	65	66	63	62		48	72
October	H	65	66	65	66	65	64	80		
	L	47	50	52	56	57	58		19	50

TABLE 1—*Concluded*

MONTH		SOIL TEMPERATURES						AIR TEMPERATURES		
		12"	24"	36"	48"	60"	72"	Maximum	Minimum	Mean
For the year 1925—Continued										
November	H	50	50	51	55	57	58	72		
	L	41	43	45	49	50	51		20	41
December	H	43	45	45	49	50	51	67		
	L	33	37	38	43	45	47		0	32
For year	H	74	72	68	68	67	65	101		
	L	33	36	37	37	40	42		−8	53
For the months January–April (inclusive) 1926										
January	H	36	39	42	44	45	48	63		
	L	32	34	36	40	41	42		−13	26
February	H	40	38	38	40	41	43	65		
	L	33	35	35	39	39	41		9	33
March	H	42	43	40	42	42	43	65		
	L	34	35	36	39	39	40		5	34
April	H	50	48	46	47	47	46	78		
	L	39	36	39	40	42	41		19	45

TABLE 2

Current practices in the United States and Canada. Record of frost penetration experiences covering a period of twenty-five years, and current practices relating to depth at which water-mains and services are now (1926) laid in various parts of the United States and Canada

NAME OF STATE OR PROVINCE AND CITY	LOWEST DEPTH OF FROST PENETRATION IN CITY STREETS, IN FEET, DURING THE LAST 25 YEARS, ENDING MARCH, 1926	DEPTH TO WHICH MAINS AND SERVICES ARE NOW (1926) LAID IN CITY STREETS, IN FEET
	feet	
Alberta, Can.		
Calgary	12	8 in loam, 10 in gravel
Edmonton	6½	8½ trench for mains; 7 trench for services
Saskatchewan, Can.		
Moose Jaw	9	9 cover
Regina		7½ cover
Ontario, Can.		
Brantford		5½ cover
Chatham	3	4 cover
Ottawa	6	6½ cover
Windsor		5 cover
Quebec, Can.		
Montreal,	5	6 trench
Manitoba, Can.		
Winnepeg,	7	7½ cover
Little Rock, Ark.		2½ trench
Sacramento, Cal.		2 cover
Colorado		
Leadville	9	7 cover
Denver		4½ cover
Colorado Springs		4½ cover
Connecticut		
Hartford	6	4 cover
Meriden		4 cover
Wilmington, Del.		3¾ cover
Tallahassee, Fla.		3 trench
Atlanta, Ga.		Mains 2½ cover; Services 2 cover
Boise, Idaho		4 cover
Illinois		
Danville	4	5 trench
Quincy	3	Mains, 4½ cover; Services 3½ cover
Chicago		5½ cover
Bloomington		3½ to 5 trench.

TABLE 2—*Continued*

NAME OF STATE OR PROVINCE AND CITY	LOWEST DEPTH OF FROST PENETRATION IN CITY STREETS, IN FEET, DURING THE LAST 25 YEARS, ENDING MARCH, 1926	DEPTH TO WHICH MAINS AND SERVICES ARE NOW (1926) LAID IN CITY STREETS, IN FEET
	feet	
Indiana		
Richmond	5	Mains 5 cover; services 4½ cover
Logansport	6	Mains 5 cover; services 3½ cover
Gary	5	5½ cover
Terre Haute	4 7/12	4½ cover
Fort Wayne		5½ trench
Elkhart		5 cover
Lafayette		4½ cover
Iowa		
Fort Dodge	7	5½ cover
Dubuque	6	6 cover
Des Moines	5½	6 trench
Council Bluffs	5	5 cover
Burlington	5	5 cover
Davenport		6 cover
Cedar Rapids		5½ cover
Kansas City, Kans		4 cover
Kentucky		
Louisville		3 to 3½ cover
Frankfort		3 cover
Baton Rouge, La		2½ cover
Maine		
Portland	5	5 cover
Biddeford		5½ cover
Augusta		5 to 5½ cover
Maryland		
Hagerstown	2⅔	3 cover
Baltimore		Mains 3½ to 4 cover; Services 3½ cover
Massachusetts		
North Attleboro	7	
Fitchburg	7	6 cover
Springfield	5⅜	6 to 7 trench
Melrose		6 cover
Haverhill		5 to 5½ cover
Lynn		5 cover
Brockton		5 cover
Fall River		5 cover

TABLE 2—*Continued*

NAME OF STATE OR PROVINCE AND CITY	LOWEST DEPTH OF FROST PENETRATION IN CITY STREETS, IN FEET, DURING THE LAST 25 YEARS, ENDING MARCH, 1926	DEPTH TO WHICH MAINS AND SERVICES ARE NOW (1926) LAID IN CITY STREETS, IN FEET
	feet	
Massachusetts—Continued.		
Beverly		5 cover
Holyoke		Mains 4½; services 5 ft.
Gloucester		4½ cover
Lowell		4 to 5 cover
Michigan		
Battle Creek	6	Mains 5 cover; services 5½ cover
Flint	5	5 cover
Detroit	5½	Mains 5 to 6 cover; Services 5 cover
Minnesota		
St. Paul	11	8 trench
Duluth	9	Mains 6½ to 7½ cover; Services 7½ cover
Minneapolis		Mains 8 to axis of pipe; Services 9 cover
Jackson, Miss	0.5	2 cover
Kansas City, Mo	2½	4 cover
Montana		
Great Falls		Mains 3½ to 12, services 5
Butte		6½ cover
Helena		5½ cover
Omaha, Nebraska		5½ cover
New Jersey		
Paterson	3½	4½ cover
Jersey City		4½ cover
Trenton		4 cover
Elizabeth		3½ cover
Camden		3½ cover
Sante Fe, N. M.	3	3 cover
New York		
Buffalo	6	5 cover
Elmira	4½	5½ trench
Syracuse	4	4½ cover
New York City	2½	4 cover
Ogdensburg		Mains 6 trench, services 5½ trench
Albany		5 cover
Glens Falls		5 to 6 cover
Gloversville		4½ to 6 cover
Rochester		4½ cover

TABLE 2—*Continued*

NAME OF STATE OR PROVINCE AND CITY	LOWEST DEPTH OF FROST PENETRATION IN CITY STREETS, IN FEET, DURING THE LAST 25 YEARS, ENDING MARCH, 1926	DEPTH TO WHICH MAINS AND SERVICES ARE NOW (1926) LAID IN CITY STREETS, IN FEET
	feet	
Raleigh, N. C.	1¼	Mains 2½ trench; Services 2 trench
Bismarck, N. D.		7 cover
Ohio		
Akron	6	5 cover
Toledo	4½	4 cover
Cincinnati	3	3½ cover
Cleveland		6 cover
Lima		Mains 4 cover; services 3½ cover
Columbus		3½ cover
Pennsylvania		
Hazleton	7½	Mains 5½ cover; services 5 cover
Erie		6 cover
Altoona		Mains 4½ cover; services 3½ cover
Pittsburgh		4 cover
Allentown		4 cover
Chester		4 cover
Harrisburg		3½ cover
Johnstown		3 cover
York		3 cover
Rhode Island		
Woonsocket	7	6 cover
Providence		Mains 4½ to center of pipe; services 4½
Salt Lake City, Utah	3	4 cover
Montpelier, Vt		5½ cover
Richmond, Va		Mains 4 cover; services 2½ cover
Washington		
Spokane	5½	4½ cover
Everett	1½	2½ cover
Seattle		Mains 4; services 2 ft.
West Virginia		
Wellsburg		4½ cover
Wheeling	3	3 cover
Clarksburg	3	4 cover
Bluefield	2½	4 cover for mains; services 2½ cover

TABLE 2—*Concluded*

NAME OF STATE OR PROVINCE AND CITY	LOWEST DEPTH OF FROST PENETRATION IN CITY STREETS, IN FEET, DURING THE LAST 25 YEARS, ENDING MARCH, 1926	DEPTH TO WHICH MAINS AND SERVICES ARE NOW (1926) LAID IN CITY STREETS, IN FEET
	feet	
West Virginia—Continued		
Parkersburg		3 to 6 cover
Charleston		3 cover
New Martinsville		3 cover
Wisconsin		
Madison	6½	6 cover
Fond du Lac		Mains 6 to 7 cover; services 5½ to 6½ cover
Milwaukee		6 cover
Kenosha		5½ cover
Cheyenne, Wyo		5 cover

Cost of instruments

THERMOMETER NUMBER	INCHES DEEP BELOW SURFACE	PRICE
304	12	$8.00
305	24	9.50
306	36	11.50
307	48	13.50
308	60	15.50
309	72	17.50
310	84	19.50
311	96	22.00

CONCLUSION

The study of year round soil temperatures below depths at which pipes are now laid has been an interesting object of research from the fact that it reveals dependable data, long sought for by the water works fraternity, and assuredly offers great promise in numerous ways to diligent investigators in the vast domain of water supply.

SECURING IMPROVED TECHNICAL SUPERVISION OF WATER PURIFICATION PROCESSES[1]

By H. E. Miller[2]

It has been requested that this paper be prepared with a view of relating briefly the developments which have taken place in improved water purification plant operation practice in North Carolina within the past few years. The paper will not, deal therefore, with the technical considerations involved, but will cover the developments in improved supervision of water purification processes with respect to how these improvements have been brought about, what has been accomplished in this connection and the end toward which this further development is directed.

The survey conducted by the California State Board of Health in 1924 tabulating the filter plants of one million gallons per day capacity, established North Carolina in third place, with Pennsylvania and Ohio holding first and second place respectively.

Ground water production is especially limited in the central and western sections of the State, and few towns ever find ground water supplies adequate after a population of 4000 or 5000 has been reached. Towns thus served usually experience water shortage before the 2500 population point has been passed. North Carolina is therefore essentially a surface water supply State.

Since 1899 there have been State laws regulating the sanitary protection of watersheds of public water supplies. Since 1905 there has been a statute requiring the monthly submission of samples of water from public water supplies to the State Laboratory of Hygiene. State Board of Health approval of plans has been required since 1911.

From 1911 to 1918 there was an engineer attached to the department, who, together with the engineer member of the Board, reviewed and passed upon plans. During that period, however, field work was not common practice, and for a portion of 1918 and 1919 there was no engineer employed. The statute establishing the Bu-

[1] Presented before the Buffalo Convention, June 8, 1926.

[2] Director of the Bureau of Sanitary Engineering and Inspection, State Board of Health, Raleigh, N. C.

TABLE 1

The public water supplies of North Carolina, December, 1921

TOWN	POPULATION	TOWN	POPULATION	TOWN	POPULATION	TOWN	POPULATION
Ground water supplies							
Shallow ground water							
Aberdeen*	858	Davidson	1,156	Linville	255	Pinebluff	165
Ayden	1,673	Hertford*	1,704	Morganton	2,867	Roxboro	1,651
Ahoskie	1,429	Jefferson	196	Monroe*	4,084	Rowland	767
Carthage*	962	Kings Mt	2,800	Newton	3,021	Scotland Neck	2,061
						West Jefferson	462
Deep seated ground water							
Beaufort	2,698	Farmville	1,780	Maxton	1,397	Red Springs	1,018
Belhaven	1,816	Franklin	1,058	Marshall	748	St. Pauls	1,147
Belmont	2,941	Franklinton	773	Mebane	1,351	Selma	1,601
Benson	1,123	Graham	2,366	Mocksville	1,146	Snow Hill	700
Chadbourne	1,121	Jacksonville	656	Morehead City	2,958	Spencer	2,510
Cherryville	1,884	Kinston	9,771	Mooresville	4,315	Southport	1,664
Clayton	1,423	LaGrange	1,399	Mt. Olive	2,297	Spring Hope	1,221
Clinton	2,110	Laurinburg	2,643	Nashville	939	Thomasville*	5,676
Dunn	2,805	Lexington*	5,254	Newbern*	12,198	Warrenton	927
Edenton	2,777	Lillington	593	Oxford*	3,606	Warsaw	1,108
Elm City	725	Lincolnton	3,390	Plymouth	1,847	Wendell	1,239
Fairmont	1,000	Maiden	1,266	Raeford	1,235	Williamston	1,800
						Windsor	1,210
						Wrightsville Beach	20

Surface water supplies

Unfiltered, sterilized, liquid chlorine							
Andrews	1,634						
Filtered, sterilized, liquid chlorine							
Burlington	5,952	Fayetteville	8,877	Hickory	5,076	Wadesboro	2,648
Canton	2,584	Gastonia	12,871	High Point	14,302	Washington	6,314
Chapel Hill	1,483	Goldsboro	11,296	Pinehurst	55	Wilmington	33,372
Charlotte	46,338	Greensboro	19,861	Proximity	10,000	Wilson	10,612
Concord	9,903	Greenville	5,772	Rocky Mount	12,742	Winston-Salem	48,395
Durham	21,719	Hamlet	3,808	Rockingham	2,509		
Elizabeth City	8,925	Henderson	5,222	Statesville	7,895		
Elkin	1,195	Hendersonville	3,720	Smithfield	1,895		
Filtered, sterilized, hypochlorite							
Albemarle	2,691	Badin	3,040	Louisburg	1,954	Raleigh	24,418
Asheboro	2,559	Bessemer City	2,176	Mt. Airy	4,752	Salisbury	13,884
						Shelby	3,609
Filtered, not sterilized							
Forest City	2,312	North Wilkesboro	2,363	Sanford	2,977	Wake Forest	1,425
Hazelwood	484	Rutherfordton	1,693	Southern Pines	743	Waynesville	1,942
Lumberton	2,691	Reidsville	5,333	Tarboro	4,568	Zebulon	953
Unfiltered, not sterilized							
Asheville	28,504	Bryson City	882	Marion	1,784	Old Fort	931
Biltmore	172	Burnsville	215	Mars Hill	364	Saluda	549
Black Mt.	531	Hot Springs	495	Murphy	1,314	Sylva	863
Brevard	1,658	Lenoir	3,718	Niagara	26	Tryon	1,067
						Weaverville	606

Laboratory control of filtration

Chemical and bacteriological

Wilmington	33,372						

TABLE 1—*Continued*

Recapitulation

TYPE OF SUPPLY	NUMBER SUPPLIES	PER CENT TOTAL NUMBER SUPPLIES	POPULATION SERVED	PERCENTAGE TOTAL STATE POPULATION SERVED	PERCENTAGE CONSUMERS PUBLIC WATER SUPPLY SERVED
Shallow ground water	17	12.7	26,111	1.0	4.4
Deep seated ground water	47	35.7	109,250	4.3	18.5
Unfiltered surface water	18	13.7	45,313	1.8	7.7
Filtered surface water	50	37.9	411,908	16.1	69.4
Totals	132	100.0	592,582	23.2	100.0
Unfiltered, not chlorinated	17	12.7	43,679	1.7	7.4
Shallow ground, chlorinated	4	3.1	7,608	0.3	1.3
Deep seated ground, chlorinated	4	3.1	26,734	1.0	5.8
Unfiltered surface, chlorinated	1	0.7	1,634	0.06	0.3
Filtered surface, chlorinated	29	21.9	325,341	12.7	55.0
Filtered surface, hypochlorite	9	6.8	59,083	2.3	10.0
Filtered surface, no sterilized	12	9.1	27,484	1.1	4.6
Chemical control, filtration	None		None		
Chemical and bacteriological control	1	0.7	33,372	1.3	5.7

* Chlorinated.

reau of Sanitary Engineering and Inspection was enacted in 1919. The primary purpose of establishing such a bureau, however, was to provide machinery for enforcing State-wide sanitation laws enacted at that time. In 1921 the bureau was put on a general appropriation basis permitting the development of its activities along the usual lines of sanitary engineering practice carried out by the State Boards of Health.

The problem encountered differed widely from that of other states with extensive water purification problems where water purification plant control had been developed to a high degree of efficiency, because it involved a large group of small and medium sized filter plants, the largest of which would, in most other states where water purification was encountered to any extent, be classified as small plants, as will be observed from tables 1 and 2.

A preliminary survey demonstrated the necessity of a wholesale reconstruction and improvement of water purification plants before much improvement in operation could be effected, because the plants were in general seriously defective, and often obsolete in design. Mechanical devices for accurate control and regulation when provided were usually out of repair and in disuse. It was found that 36 of the 50 filter plants would either have to be replaced by new plants or would have to be reconstructed to an extent almost equivalent to new plant construction. Major repairs and overhauling were necessary in 10 plants and 4 required only certain minor improvements. These figures are based on a comparison of plants then existing to the then accepted and generally recognized standards of water purification practice. There are now a total of 78 filtered water supplies, most of which have already been made to conform in most respects to accepted standards of modern water purification practice, the remainder of which are either under construction, the contract has been let, or the engineers have been employed and funds provided.

Technical supervision with complete laboratory control was practiced in only one plant. This plant had been so operated for 10 years, but the practice had not been adopted by any of the other plants in the state. Alkalinity determinations were made in a few of the other plants. For the most part, however, the application of chemicals was determined by visual observation of the water and strictly rule of thumb procedure.

With all the shortcomings of water purification equipment and

TABLE 2

The public water supplies of North Carolina, January, 1926

TOWN	POPULATION	TOWN	POPULATION	TOWN	POPULATION	TOWN	POPULATION
			Ground water supplies				
			Shallow ground water				
Aberdeen	890	Boone	471	Kings Mt.	3,091	Pinebluff	212
Ahoskie	1,681	Carthage	1,012	Linville	350	Robersonville	1,491
Aulander	933	Danbury	225	Lynn	100	Rowland	767
Ayden	2,014	Enfield	1,888	Marshville	748	Scotland Neck	2,228
Bakersville	332	Jefferson	202	Monroe	4,086	Spindale	2,250
				Niagara	110	West Jefferson	462
			Deep seated ground water				
Beaufort*	3,210	Fremont	1,466	Maxton	1,435	Snow Hill	825
Belhaven	1,816	Gibson	264	Mocksville	1,188	Spencer	1,807
Belmont	3,823	Gibsonville	1,372	Morehead City*	3,417	Southport	1,754
Benson	1,284	Graham	2,366	Mt. Gilead	1,001	Spring Hope	1,221
Cary	796	Hookerton	339	Mt. Olive	2,910	Stantonsburg	524
Chadbourn	1,121	Jacksonville	745	Nashville	1,034	Star	581
Cherryville	2,249	Kannapolis	6,000	Newbern*	13,312	Taylorsville	1,352
Clayton	1,423	Kenansville	318	Norwood	1,367	Troutman	398
Clinton	2,615	Kernersville	1,264	Plymouth	1,847	Walnut Cove	736
Cordova	350	Kinston	11,159	Polloksville	395	Warrenton	987
Edenton	2,771	LaGrange	1,519	Raeford	1,562	Warsaw	1,300
Elm City	793	Lillington	699	Red Springs	1,018	Whiteville	1,812
Elon College	537	Lincolnton	3,878	Roseboro	1,032	Wendell	1,479
Fairmont	1,135	Littleton	1,010	St. Pauls	1,511	Williamston	1,913
Farmville	2,262	Madison	1,354	Selma	1,736	Windsor	1,473
Franklin	970	Maiden	1,567	Siler City	1,432	Wrightsville Beach*	2,000

Surface water supplies

Surface water supplies

Unfiltered, sterilized, liquid chlorine

Andrews	1,983	Cullowhee	550	Marshall	748	Sylva	946
Asheville	33,375	Dillsboro	228	Morganton	2,945	Tryon	1,250
Biltmore	172	Hendersonville	4,171	State Hospital, Morganton	2,000	Weaverville	688
Black Mt.	641	Lake Junaluska	2,550	Murphy	1,532	Highland	356
Brevard	2,027	Lenoir	3,895	Saluda	706	Hot Springs†	521
Bryson City	1,017	Marion	1,916	Spruce Pine	717	Old Fort†	1,007

Filtered, sterilized, liquid chlorine

Albemarle	2,978	Elizabeth City	9,181	Laurinburg	2,803	Salisbury‡	17,249
Apex	1,048	Elkin	1,350	Leaksville	1,849	Samarcand	350
Asheboro	2,905	Fayetteville	9,793	Lexington	5,799	Sanford	3,324
Badin	3,250	Forest City	2,672	Louisburg	2,043	Sanatorium	375
Bessemer City	2,999	Franklinton	1,183	Lumberton	2,921	Shelby	3,850
Burlington	6,524	Gastonia	16,427	Mebane	1,680	Smithfield	2,169
Burnsville	450	Goldsboro	13,890	Moncure	100	So. Pines	844
Canton	3,179	St. Hospital‡ Goldsboro	500	Mooresville	4,752	Statesville	9,543
Chapel Hill	4,000			Mt. Airy	6,306	Tarboro	4,787
Charlotte	52,500	Greensboro Proximity Mfg. Co.	45,529	Mt. Holly	1,477	Thomasville	6,575
Clyde	373			Newton	3,373	Troy	1,126
Columbus	191	Greenville	6,607	N. Wilkesboro	2,593	Wadesboro	2,784
Concord	10,497	Hamlet	4,625	Oxford	3,905	Wake Forest	1,425
Conover	811	Hazelwood	512	Pinehurst	2,100	Washington	6,365
Cramerton	2,850	Henderson	5,581	Raleigh	29,771	Waynesville	1,942
Davidson College	1,206	Hertford	1,704	Reidsville	5,585	Weldon	1,872
Dunn	3,296	Hickory	5,757	Rockingham	2,686	Wilkesboro	821
Durham	42,258	High Point	23,038	Rocky Mount	15,087	Wilmington	38,708
		Jonesboro	929	Roxboro	1,764	Wilson	12,554
		Jonesville	875	Rutherfordton	2,009	Winston-Salem	65,806
						Zebulon	1,177

TABLE 2—*Continued*

Recapitulation

TYPE OF SUPPLY	NUMBER SUPPLIES	PER CENT TOTAL NUMBER SUPPLIES	POPULATION SERVED	PERCENTAGE TOTAL STATE POPULATION SERVED	PERCENTAGE CONSUMERS PUBLIC WATER SUPPLY SERVED
Shallow ground	22	11.8	25,543	0.93	3.1
Deep seated ground	64	34.0	119,904	4.34	15.3
Unfiltered surface	24	12.7	65,941	2.38	8.2
Filtered surface	78	41.5	573,442	20.72	73.4
Totals	188	100.0	781,582	28.37	100.0
Unfiltered, not chlorinated	2	1.0	1,528	0.05	0.2
Shallow ground, chlorinated	6	3.9	11,957	0.44	1.5
Deep seated ground, chlorinated	4	2.1	21,939	0.88	2.8
Unfiltered surface, chlorinated	22	11.7	64,413	2.40	8.2
Filtered surface, chlorinated	78	41.5	573,442	20.72	73.4
Chemical control filtration	26	13.8	54,768	2.03	7.0
Chemical and bacteriological control	44	23.4	501,653	18.32	64.2

* Chlorinated.

† Not chlorinated.

‡ Hypochlorite.

operation control which were probably no worse than the conditions of the average state at that time there is but one water borne epidemic of typhoid fever charged to the history of the State. This is principally due to the influence of earlier water supply legislation regulating the sanitary control of watersheds and requiring regular bacteriological examinations.

In view of the fact that it was found that a wholesale reconstruction of filter plants would have to take place before any system of operation could in general be relied upon for effective results, attention was first concentrated upon securing reconstruction and

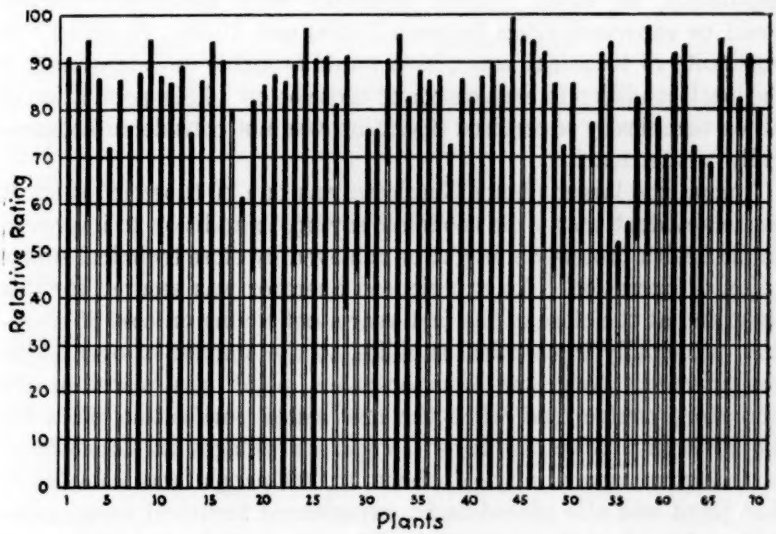

FIG. 1. IMPROVEMENT IN EQUIPMENT OF FILTRATION PLANTS JANUARY, 1921, TO MAY, 1926

improvement of filter plants. Since this paper is a discussion of the development in operation control, however, the construction developments will be given only passing mention. The reason many of the plants range around the 90 per cent line, as shown in figure 1, is that this chart actually represents the character of the water supply system and deductions have been made for cross connections and other features not properly chargeable against the plant. (This chart, as well as the chart and curves which follow, was derived by means of a system of evaluation, details of which are not within the scope of this paper, and is in no sense intended as a system of scoring

either filter plant equipment or operation. It is simply an arbitrary measurement of extent of compliance with generally recognized best practice. The data are taken from office records, primarily intended only for the guidance of our own organization, and are used here simply because they represent the most convenient method at hand for illustrating relative progress.)

In the light of the prevalent opinion among water purification men there seemed to be little doubt as to the justification of technical supervision and laboratory control of the 6 larger plants. The supplies were therefore grouped as follows: The cities of over 25,000 population, in which trained operators with laboratory control could be expected; cities between 25,000 and 10,000, in which the possibility of technical supervision would probably be determined by the local condition in each case; and those below 10,000 population in which technically supervised operation was not considered economically within reach.

Among the larger plants Charlotte was one of those in which it seemed evident that a big economic saving, in addition to improved public health protection, might be achieved by close technical supervision of operation. An experienced operator was secured for this plant and at the close of the first year a net saving on cost of operation, principally in chemical supplies, to the amount of over $5000 was effected. Next the Winston-Salem plant was placed under laboratory control and when the new water purification plant for the Proximity Manufacturing Company's villages at Greensboro, an industrial community of about 10,000 people was completed, that plant was also placed under experienced technical supervision.

Thus far, all of the men obtained for this work had to be secured from out of the State causing our cities to pay a premium over what one might expect to pay for men of the same qualifications and experience if available locally. The difficulty was that such men were not available locally, which presented the unmistakable problem of training and developing them.

Operation improvement was undertaken along two different lines:

1. The systematic training and development of the practical operators, those not trained in the science of water purification.

2. The systematic development of operators especially trained in the science of water purification.

In the training of practical plant operators, men of widely varying degrees of education were encountered. They were trained by

degrees, first in the principles, operation, care, checking, and maintenance of equipment and mechanical devices. Next the simpler

TABLE 3

Laboratory control of filtration

Chemical			
Albemarle	978	Jonesville	875
Burnsville	450	Lumberton	2,921
Conover	811	Mebane	1,680
Cramerton	2,850	Moncure	100
Clyde	373	Newton	3,373
Elizabeth City	9,181	Roxboro	1,764
Elkin	1,350	Rutherfordton	2,009
Davidson College	1,206	Samarcand	350
Franklinton	1,183	Tarboro	4,787
Gold. St. Hospital	500	Troy	1,126
Hertford	1,704	Wadesboro	2,784
Hickory	5,757	Wake Forest	1,425
Louisburg	2,043	Zebulon	1,188
Chemical and bacteriological			
Apex	1,047	Lexington	5,799
Asheboro	2,906	Mooresville	4,572
Badin	3,250	Mount Airy	6,306
Bessemer City	2,999	Mount Holly	1,477
Burlington	6,524	N. Wilkesboro	2,593
Chapel Hill	4,000	Oxford	3,905
Charlotte	52,500	Raleigh	29,771
Concord	10,497	Reidsville	5,581
Dunn	3,296	Rocky Mount	15,087
Durham	42,258	Salisbury	17,249
Fayetteville	9,793	Sanatorium	375
Forest City	2,672	Smithfield	2,169
Gastonia	16,427	Southern Pines	844
Goldsboro	13,890	Statesville	9,543
Greensboro Proximity Mfg. Co.	45,529	Thomasville Weldon	6,575 1,872
Greenville	6,607	Wilmington	38,708
Hamlet	4,625	Wilson	12,554
Henderson	5,581	Winston-Salem	65,806
High Point	23,038	Washington	6,365
Laurinburg	2,803	Wilkesboro	821
Leaksville	1,849	Rockingham	2,686

chemical and physical determinations were taken up and for several years this class of men have also been taught the practical use of

pH determinations. Those who demonstrated sufficient interest and capacity were also taught bacteriological determinations, beginning with plate counts and the detection of gas formers and confirmation.

Since the plants were not then equipped with the necessary laboratory facilities it was essential to secure the installation of simple laboratory equipment before any training in work involving laboratory determination could be successfully undertaken. These laboratory sets are simple and relatively cheap, but are adequate for the simple determinations required in most plants. The approximate cost of the chemical test set and the bacteriological set is respectively, $30 and $400. In all the plants where laboratories are installed, see table 3, these sets have been used, except in a few of the larger plants which are equipped for more extensive laboratory work.

All this work had to be taught by rule of thumb first, then followed up with the explanation of principles and application in control of the process. In the course of this work there has been developed a bulletin of instructions for filter plant operators. This bulletin, known as 211, was written with the sole purpose of explaining technical problems to laymen in non-technical language.

The results accomplished in this training process were so far in excess of what was anticipated and some of the operators have developed such capacity and interest in the further study of the basic scientific principles that there has been a filter operators' correspondence course prepared for their further development. In this course labeled diagrams are used with explanations of the physics, mechanics and hydraulics of all the common filter equipment and appurtenances; the simpler chemistry of filtration is explained giving digests of some of the text material and specifying reading assignments in general chemistry. The routine bacteriology is covered in the same way as chemistry. In connection with this course questions have been prepared for the operator's use in submitting written reviews.

A remarkable change in the operator's attitude toward his work has usually been observed. Operators who were previously not concerned as long as the filter effluent came through relatively clear, now check the plant equipment and watch their laboratory results religiously for any indication of irregularity of performance.

While this type of operator, in charge of all the supplies having only chemical test sets and 22 of the 44 supplies provided with both

chemical and bacteriological sets, is incapable of pursuing any appreciable research into water purification and cannot, except to a limited extent, apply anything but rule of thumb measures to operation procedure, a vast improvement in the operation efficiency in many small plants has been accomplished by thus utilizing the available personnel as far as possible. This fact partially accounts for the gains shown in figure 2.

This plan of training has proven particularly valuable in the case of some of the very small plants, where the personnel is limited and the superintendent often plays a double rôle, attending to the

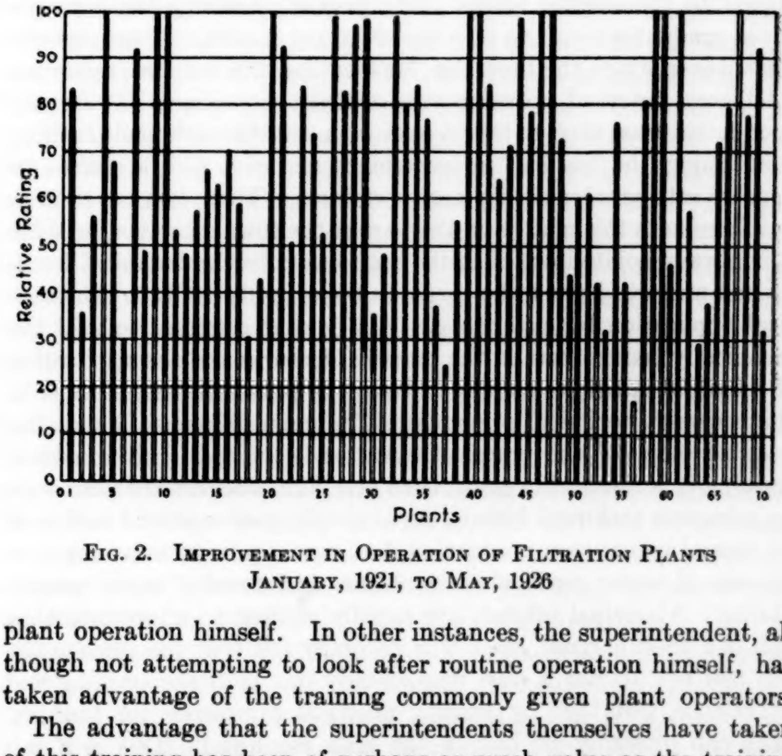

Fig. 2. Improvement in Operation of Filtration Plants January, 1921, to May, 1926

plant operation himself. In other instances, the superintendent, although not attempting to look after routine operation himself, has taken advantage of the training commonly given plant operators.

The advantage that the superintendents themselves have taken of this training has been of perhaps as much value as the training of operators in the advancement of improved operation efficiency. With this better understanding of the problem by the superintendent, the needs of the plant in all respects, including the type of personnel best adapted to plant operation, are given more consideration and have a far better chance of being adequately provided for in the general administration of the water works department.

The systematic development of technically trained men was begun in the college classroom. Although this is a slow process, it is believed to be the best way to develop thoroughly capable men.

The normal lines of development of a young engineer or chemist into a capable operator would seem to be first as assistant in a larger plant and later to assume charge of a plant himself. Having no large plants, however, that could afford such men as assistants, other measures had to be considered. Much to our surprise, and it is believed out of line with the ordinary conception, it was found that these men could not only be used to advantage, but had a strong appeal to the smaller towns. The prevailing salary for inexperienced graduates seems to be about $125 per month. There are few instances in which the town can, for less than this amount, secure an intelligent practical operator even without experience. It is only good horse sense then to take a man with suitable technical training, even though he has had no experience and give him a chance to develop into greater ability and usefulness. There has never been any illusion in this matter on the part of the town, however, because it is always pointed out that the man has only the technical background and will have to be given an opportunity to learn the practical application by experience. It is just as essential to drill the technically trained man in the practical features and the application of scientific principles as it is to train the practical man in some of the necessary technical principles. The main difference is that the possible scope of the practical operator is limited, with whatever training it is reasonably possible to give him, whereas the man with an adequate technical foundation is simply good material and is of no special value upon graduation, but can acquire a larger comprehension of water purification problems and develop much greater ability. Municipal officials are rapidly coming to appreciate that this is a good bargain, since it is generally felt that the pay for the job will not attract a man who already has both the training and experience, but that by trading practical experience for training, both can presently be had in the man employed. This is a fair trade both ways.

While the development of both chemists and civil engineers has been successfully undertaken, the combination making up the sanitary engineering training provides the most suitable background, but to a certain extent good filter operators like heroes are born, not made.

Our colleges have shown special interest in developing training for the better preparation of men particularly interested in this field of work. The assignment of students to water works plants in connection with the coöperative course in civil engineering at the University of North Carolina has proven an exceedingly valuable aid.

The mere employment of an inexperienced man of whatever training would of course fall far short of providing adequate technical supervision of operation. It is especially emphasized that it is not intended to convey the impression that these inexperienced men can, unassisted, be entrusted with the responsibility of a filter plant or become proficient if left to work out their problems without proper guidance. All such raw material has to be trained and developed. This is systematically carried out in each case, beginning with the assignment of an engineer experienced in filter plant operation, who actually does all the work at first, gradually making the operator assume more and more responsibility until he is fully established. The engineer stays on the job constantly with the operator until he is well established in the plant routine and returns to assist him at frequent intervals, keeping a close check on his work in the meantime by means of detailed daily records of plant operation and tests.

Further experience with the development of this type of operator in the small plant continually reveals new lines of valuable service by which the town may profit as the result of having such an employe. The experience of one town in this connection naturally illustrates to others the value of such service, and thus by working out the combination of certain related activities technically trained men are employed on small plants where the local officials would not otherwise feel justified in providing such supervision. One of the most important illustrations of other fields of usefulness helping to develop technical supervision of small plants is the adaptation of the plant laboratory to milk tests. Towns having a population of from 2000 to 5000 do not usually have over 4 or 5 dairies. It has been found quite practical in such cases not only to have the milk testing done at the plant laboratory, but also to have the dairy inspection done by the operator. Where the dairy inspection is done by some part time employe a figure of $75 per month for towns of this size seems quite well established. If the operator does this work too, the town secures the necessary protection in the control of the safety

of both water and milk supplies and enjoys a net saving over the cost of less satisfactory methods of handling both problems.

Where milk testing or dairy inspection work are taken up the operator is also given special training in this work by a specially qualified representative of the State Board of Health in which the same general plan as that used in plant operation training is followed.

Many other fields of valuable service have been developed such as assisting the superintendent in drafting, surveys, mapping, and location of underground structures, and other work for which the training of the engineer is especially applicable. The principal difficulty now encountered is to find sufficient suitable raw material to fill the demand. In this way the development in improved public health protection has taken place in such manner that every dollar expended toward this end has not only been amply justified in the greater protection accomplished, but has returned a good economic dividend to the town in actual dollars and cents.

Each man has before him a reasonable field of advancement. Operators' salaries at present range from $4000 per year down to $1500 per year for beginners.

This line of experience provides an invaluable background for men on investigation and design in water and sewage purification work, with consulting engineering firms. Furthermore, the rapidly growing problem of sewage treatment with which North Carolina cities are being confronted makes possible a wider scope of activity and consequent increased value of such service to municipalities.

All of these possibilities have been clearly demonstrated in this calendar year. The operator of one of the larger plants accepted a very attractive position with a consulting engineering firm. His successor was secured at a material salary advance from one of the other larger plants. This salary was partially based on the fact that he had experience especially fitting him for handling an important problem of regulation of sewage treatment. His successor was of less experience from a smaller city of the same group, who accepted the vacancy at a material salary increase. This man's successor in turn, was a still less experienced operator from one of the group of small plants who made the change partially for the better professional recognition afforded and for a small salary increase. The average salary increase was $600 per year. Two other individual advances to new locations have taken place in the same period, leaving openings in each case for the starting of new in-

experienced men. One of the changes was made at a salary advance of $900 per year and the other at $600 per year.

Operators are started in plants not far in excess of their ability, and have an opportunity to develop systematically and progressively into larger plants and greater responsibility. It is interesting to observe, however, that what was originally intended primarily as a means of development of operators to a point of sufficient ability and experience to handle the larger plants, has turned out to be the main field of activity. The need, the justification, and the value of such service in small plants have been demonstrated as sufficient to establish the small plant along with the large plant in the technical supervision of operation, with experience requirements and salary remuneration fairly in proportion to the position of the town in the population scale. Thus with the operators in plants of all sizes, equipped with training and experience meeting the needs of each case, men of suitable qualifications may be had locally for any plant from the largest to the smallest. Thus far, the purification processes for 22 of the filtered water supplies are regulated under technical supervision of men especially trained in the science of water purification, aided by complete plant laboratory control. Only four of these men were qualified with filtration experience when employed, all the others have been developed through the plan of training described.

Although this discussion is primarily concerned with improved technical supervision of water purification processes, failure to recognize the fact that improvement in all lines of water works practice throughout the State, partially represented in figures 3 and 4, has been quite consistent with the progress in improved operation control, would be an unpardonable omission.

In addition to the factors which have been cited as having exerted an important influence upon the progress in water supply improvements, the North Carolina Section of the American Water Works Association is more responsible for the improved water works practice, generally and specifically, than any other contributing factor that has come to our aid. Few small town water works men attend the national conventions. The small town employee would find himself utterly lost in the maze of technical discussions common at the national conventions. The State Section has brought the water works men together from all sizes of systems, and has made available a common meeting place in reach of all. The discussions

are sufficiently in the language of the layman to be understood by the average water works man and include the more common local problems. The water works men of the small town, heretofore isolated with no scope outside the boundary of his own water works system, has broken the narrow confines of his range of knowledge of water works problems, is familiar with the advances taking place

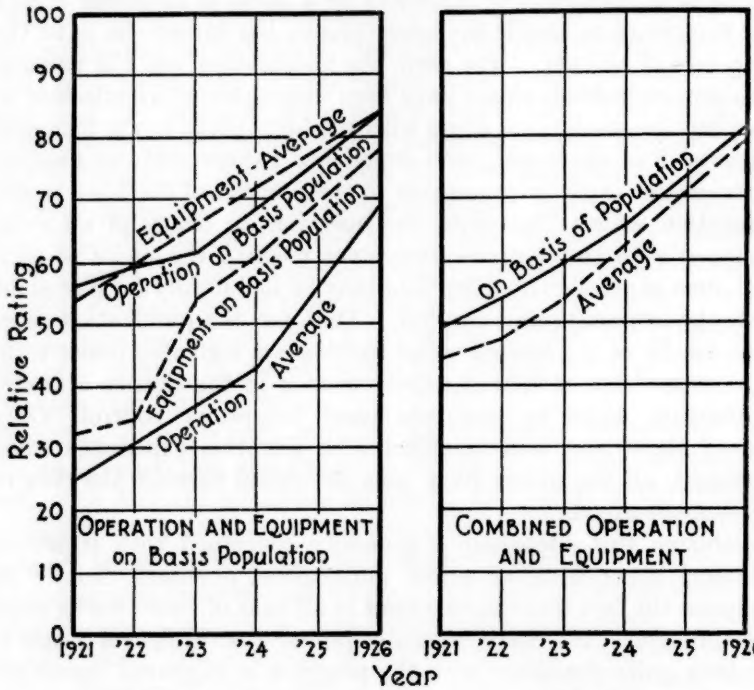

Fig. 3 Fig. 4

Figs. 3 and 4. Improvements in Filtration Plants

in water works practice and strives to hold his place in the constant march forward. This is not theory or supposition, but is a proven fact clearly demonstrated in the advance shown by the average water works man in his knowledge and understanding of the daily problems and in the general interest which prevails.

The influence of this Section has been sufficient to justify the statement that any man, from a state which has no local section, can do more for the advancement of water works practice in his state and the improvement of his own efficiency by helping in the organization and development of a live local section than by any other means.

EXPERIENCE WITH THE USE OF DE LAVAUD CENTRIFUGALLY CAST IRON PIPE[1]

KENOSHA, WISCONSIN

By P. J. Hurtgen[2]

The City of Kenosha with a population of over 52,000, had, at the first of the year, 92.10 miles of water mains. The entire water distribution system is constructed of cast iron pipe ranging in size from 24 to 4 inches. During the last five years, however, no pipe smaller than 6 inches has been purchased.

A steady pressure of 65 pounds is maintained at the pumping station, which gives a pressure of 45 to 58 pounds at the hydrants. In case of a fire the pressure at the plant is increased to 75 pounds, a material pressure increase being unnecessary for the fire department is equipped with sufficient pumpers to care properly for the fighting of fires.

In November, 1923, in order to complete our year's program of main extensions it was found necessary to order an additional carload of 6 inch water pipe. We, therefore, purchased 167 lengths (2004 feet) of 6 inch de Lavaud cast iron pipe. Up to this time we had been using Class "C" sand cast pipe, which stands a working pressure of 130 pounds per square inch. The manufacturers of the de Lavaud pipe substitute for the Class "C"—6 inch pipe, a pipe that has a working pressure of 150 pounds per square inch.

When our carload of de Lavaud pipe arrived it was run into our pipe yard. It was unloaded with a crane onto our wagons and delivered to the job. The delivery of all our pipe to the jobs is made by one man. The yard man helps to load the pipe, and the teamster hauls them to the job and strings them out on the proposed work by rolling the pipe off the wagon and dropping them on the ground. Our water main extensions are, for the most part, on

[1] General discussion before the Joint Session of the Divisions of Plant Management and Operation and Fire Protection, Buffalo Convention, June 11, 1926.

[2] Director of Public Works, Kenosha, Wis.

unpaved streets. The pipe are strung along the gutters which are more or less soft and grown up with grass and provide a reasonably soft cushion for the pipe to drop on. The teamster unloads the pipe without additional help. Of the 167 pieces delivered on the job and unloaded in this manner we found 12 pieces that had been fractured. Some of this may have been broken on the car while in transit; and because of the fact that we find so few of the sand cast pipe broken while in transit, it is possible that, while unloading the pipe, the men did not make as close an inspection as they should have to determine how many, if any, were broken before arrival at our yard. Most of these pipes were used on short extensions.

On one job on which these pipes were used the ground had frozen to a depth of several inches. The pipe was frozen to the ground and the workmen loosened it by inserting a wooden pry on the spigot end of the pipe and giving the pry a quick snappy jerk upwards as they were accustomed to doing with the sand cast pipe. But by using this same method they broke small pieces out of the end of the pipe. Following this experience we used a pick on the pipe that could not be loosened by prying lightly. But by picking under the spigot end of the pipe we cracked several pipes. The cracks appeared about a foot from the end of the pipes. In view of these experiences we concluded that in handling the de Lavaud pipe we couldn't "treat 'em rough." Therefore, when laying these pipes instead of one man dropping the pipe into the trench we used two men and let the pipe down with ropes. By doing so no pipes were broken while placing them in the trench, although it required one extra man.

On another short extension where this pipe was used, the foundation was somewhat murky and soft and after the pipe was laid a leak developed which necessitated digging up the main. In this case the pipe had settled at the ends probably because of digging the bell holes too deep and the pipe broke in the center.

On one of these same jobs another leak developed at a point where a tap had been made, and when we dug down to the main we found the pipe cracked for a distance of about 6 inches on each side of the tap.

This pipe appears to be harder and more brittle than sand cast pipe, which, I believe, accounted for the cracked pipe. Because of this hardness we found that it required considerably more time to make a tap than the sand cast pipe required. We found also that because of the hardness the drills had to be sharpened more often.

In cutting this pipe to make connections we cracked a couple pipes, although we followed the same method as we used in cutting the sand cast pipe. Following this experience we used a sharper chisel and struck lighter blows, and eliminated this trouble.

The City of Kenosha Water Department calls for bids on its estimated pipe requirements in January or February of each year and the contract is let to the lowest bidder. After the contract is awarded arrangements are made with a testing laboratory for the testing of all water pipe contracted for. We pay 30 cents per ton for this service.

A statement of the laboratory test on the de Lavaud pipe might be of some interest. The laboratory report showed that 196 pieces of pipe were tested. Of this number 29 were rejected and 167 pieces, which was the amount of our order, were accepted. The causes of rejection were light weight and inside roughness. All the pipe was tested to 300 pounds hydrostatic pressure. The test provided a breaking strain of 2480 pounds and deflection of 0.36 inches. The pipe rejected at the laboratory foundry amounted to 14.8 per cent of the pipe tested.

This appeared to me to be rather high and I, therefore, made a comparison of the laboratory tests on sand cast pipe. One of these reports showed that of one lot of 182 pieces tested in January of this year only 5 pieces were rejected. These pieces were rejected because of broken bells, cracked bells and core scab. This test provided for a breaking strain of 2200 pounds and a deflection of 0.38 inch. The pipe rejected in this lot amounted to 2.7 per cent of the pipe tested. From another lot of 217 pieces of sand cast pipe only one or less than one half of one per cent was rejected. This rejection was made because of sand holes.

The average weight of a carload of de Lavaud pipe was 25.3 pounds per foot, while the average weight of the sand cast pipe of the same class was 35.8 pounds per foot.

The difference in cost between the sand cast Class "C" pipe and Class "150" de Lavaud pipe in 1923 when we purchased the pipe was 4 cents per foot in favor of the de Lavaud pipe.

We are at the present time using Class "B" sand cast pipe and at the time we contracted for our pipe, which was in January of this year, the de Lavaud pipe could have been purchased for about $6\frac{3}{4}$ cents per foot less than the sand cast pipe. The difference, however, is absorbed by the extra labor necessary in handling the centrifugally cast pipe.

Nearly all of the difficulties that we encountered in the use of this pipe, particularly in the handling, could have been eliminated had we been familiar with the peculiarities. Had we used two men instead of one in handling the pipe, breakage from handling could have been eliminated. Had we loosened the pipe frozen to the ground by placing the pry in the bell end we possibly would have broken no pipe.

In making our water main extensions we use a gasoline driven trench excavator and backfiller. Our construction crew consists of one operator for the trenching machine; two spud men, except where digging in hard clay soil when only one spud man is necessary. One man takes care of the lead kettle and drops the pipe into the trench; one bottom man digs the bell holes and one operates for the backfiller. As previously stated, when using de Lavaud pipe we used two men to drop the pipe into the trench.

The disadvantages of the de Lavaud pipe as I see them may be summed up as follows:

Requires two men to string pipe along line of work.

Requires two men to lower pipe into trench.

Requires more time to make a tap.

Drills wear out and become dull more quickly on this make of pipe.

However, the de Lavaud pipe has a fine smooth finish both inside and outside. The 6-inch pipe has an internal diameter of $6\frac{1}{4}$ inches, which gives you an increased carrying capacity over the sand cast pipe. The wall thickness is surprisingly uniform, and the pipe presents a very neat and uniform appearance.

I do not want to go on record as condemning the de Lavaud pipe, but I have related actual experience with the use of de Lavaud pipe with the hope that you who contemplate using it may profit by our experience.

KNOXVILLE, TENNESSEE

By Frederick W. Albert[3]

Knoxville's first use of centrifugally cast iron water pipe might be called an accident.

Almost immediately after assuming the duties of Engineer in Charge of the Water Department, in May, 1924, plans were perfected

[3] Engineer-in-Charge, Water Department, Knoxville, Tenn.

for the completion of the 5th Avenue Underpass. This called for an extension of approximately 1200 feet of 12-inch water main. Owing to the unorganized condition of the department, requisitions for materials were seldom made until needed, and then only in amounts required by the project in hand. The progress of the work on the Underpass called for considerable activity on the part of the Water Department, if they were to complete their part of the project ahead of the paving contractor.

All foundries approached on the subject of shipping us our requirements of 12-inch standard cast pipe stated that deliveries could not be made before 60, 90, and in one case 120 days. This could not be considered, so a long distance call from the Birmingham Office of the United States Cast Iron Pipe and Foundry Company, to the effect that they could ship us immediately our requirements in the form of Class 150 de Lavaud centrifugally cast iron pipe, was looked upon as a happy solution of our problem. The pipe was duly ordered and received in a very few days, being immediately delivered to the ditch.

Conscious of the fact that Knoxville had never before used their De Lavaud product, the United States Cast Iron Pipe and Foundry Company sent a man here, immediately after the arrival of the pipe, to instruct us in the handling of the de Lavaud pipe. His remarks were few, but to the point. We were not to handle the pipe as we had the standard cast iron pipe, but instead, the pipe was to be handled with care, as the shell was much thinner than standard cast pipe, and due to the nature of the casting, different in composition. In cutting the pipe, heavy sledge-hammer blows and dull cleavers were not to be used; instead, sharp cleavers and light blows with an 8-pound hammer would produce a cut as clean and sharp as if turned off in a lathe.

Being unfamiliar with this pipe the men worked cautiously and followed instructions carefully. The result was that this initial section was laid and tested out 100 per cent perfect. In consequence of this initial order, the United States Cast Iron Pipe and Foundry Company prevailed upon us to specify de Lavaud centrifugally cast iron water pipe as an alternate in our requisitions for pipe subsequently made.

The price differential in favor of the de Lavaud pipe on the basis of per foot laid, combined with our belief in the product, resulting from our initial experience and our later study, induced us to buy

this type of pipe. This we have done continuously to date, in all sizes used in Knoxville, from 4 to 16 inches. The 24- and 30-inch pipe which we are now installing is of the standard cast make, largely because these sizes are not now made by the de Lavaud process. In all, we have contracted for and installed approximately 150,000 feet of sizes from 4 to 16 inches inclusive. The majority of this, however, is 6-inch pipe.

Our experience with this pipe leads me to believe that there is a direct relation between the portability and the size. For instance, we have practically no trouble with the 4-inch de Lavaud pipe. In proportion to the amount used, our trouble was slightly greater in the 6-inch size. This trouble increased with the 8, was greatest in the 10-inch and diminished slightly with the 12- and 16-inch, to the end that in the 16-inch size we have had practically no trouble whatever. There is this difference however, the 16-inch size is made in 4 classes, whereas the smaller sizes are only made in three classes.

The trouble mentioned above is in the nature of cracks of greater or less lengths, presumably resulting from shock and rough handling in transit. All pipe we assume to be carefully inspected and pronounced sound when it leaves the foundry, not only by the foundry officials, but by the testing laboratory representative whom we employ to inspect these materials. Upon arrival in Knoxville the pipe is again inspected by our own, as well as by the railroad inspector.

The cement lining which we specify to be placed in all our cast iron water mains materially prevents detection of the hair-line cracks through the hammer test. For our further protection we require our inspector to carefully examine the spigot end of the pipe with a magnifying glass, which in many cases discloses cracks which do not appear present under the hammer test.

All cracked pipe is marked and noted by our inspector and the railroad officials, and then hauled direct to the job. The hauling is done by an experienced contractor, who under the direction of our inspector, is required to exercise extreme care in unloading the pipe on to their trucks, and in placing the pipe on the ground. De Lavaud centrifugally cast iron pipe and insofar as our experience is concerned, the same thing applies to other centrifugally cast iron water pipe, cannot be handled with the freedom of action characteristic of standard cast iron water pipe. The fabrication develops greater tensile strength at the sacrifice of toughness. This the foundry attempts to overcome by a special cooling proc-

ess after the pipe is cast. They are conscious of their inability to retain the tough characteristics of standard cast iron water pipe, when they caution users of the centrifugally cast iron water pipe as they did in our case.

However, if aware of the more or less brittle nature of the centrifugally cast iron pipe, and if the personnel are properly instructed, not only in the cutting of this pipe, but in the handling of it through all of the various stages, from car into the ditch where it is expected to lie for many years to come, I see no reason why centrifugally cast pipe is not as good as standard cast iron pipe, of the same size.

If the consumer buys water pipe, f.o.b. Foundry, he gets, through the de Lavaud process, a pipe with higher tensile strength at a lower cost per foot of pipe, as well as lower freight bills.

An organization that is not interested in this lower cost and not desirous of handling the product according to its requirements, should not consider de Lavaud centrifugally cast iron pipe.

Our experience with the United States Cast Iron Pipe and Foundry Company who have furnished us with all our de Lavaud pipe, prominently brought out two points; (1) Deliveries of all sizes could be made practically immediately. (2) The company stood back of its product, not only in transit, but for many months after the pipe was in the ground. This service we believe to be worth the careful handling which de Lavaud pipe requires, for in many cases the hair-line fractures do not cause the pipe to fail for some considerable time after it has been placed in the ground and has been subjected to the normal working pressure of the system.

There was one point I failed to mention above which I think should be considered.

De Lavaud pipe is cast with a bell, but without a bead on the spigot end. This, I believe to be a point worthy of extreme consideration on the part of the purchaser, for unless he is watchful and carefully blocks the dead-end of a line of de Lavaud pipe, the pressure against the unsupported plug or closed valve, easily shoves the pipe out of the bell and causes damage through leaks, usually large in size.

This, as you know is not true of standard cast pipe, or any pipe which has a bead on the spigot end, as the action of the pressure tends to force the bead against the lead with the result that there is a compression at that point usually greater than the force which tends to slip the pipe through the joint.

If the purchaser, however, is conscious of this short-coming in the de Lavaud pipe and I believe it is a decided short-coming, and plans his work to prevent accident and blown joints, I see no reason why the absence of the bead on the spigot end should work a hardship. Here, again, I feel that the disadvantage is more than off-set by the advantages which pertain in the use of de Lavaud pipe.

RECAPITULATION

1. I believe that de Lavaud centrifugally cast iron pipe is the best purchase for Knoxville, Tenn., because of the lower initial cost, greater tensile strength and better service by the foundry, as compared with the standard cast iron water pipe.

2. Owing to the thinner shell and consequent lighter weight, as well as to the nature of the cast iron in the de Lavaud pipe, it does not possess the same toughness which standard cast iron water pipe has, and therefore requires special training of the personnel in cutting the de Lavaud pipe, as well as in its handling.

3. Owing to the lighter weight and greater speed in casting, as well as to other factors incident to its fabrication, de Lavaud pipe will eventually be so much cheaper that it will be generally used in preference to the standard cast iron water pipe.

MACON, GEORGIA

By R. E. Findlay[4]

Looking backward through the dim perspective of years, one of my earliest recollections is the interest I manifested in foundry work, when as a boy just rounding into my teens I spent all my time available from school in watching the molders at work in my father's iron foundry. For me this work became so fascinating that I later decided to learn the trade. After serving an apprenticeship covering the requisite number of years I was pronounced a full-fledged molder. However, at this period my father decided that my career should lie in other lines, but I have never regretted my foundry experience, nor have I ever lost interest in the work.

A few years ago, when I first heard of centrifugally cast pipe, cast on a steel cylinder that served as flask and mold, to use the vernacular of the street, I immediately sat up and took notice. I

[4] Secretary and Treasurer, Board of Water Commissioners, Macon, Ga.

could understand, of course, how the manufacture could be effected, but what of the product? How could the chill be overcome? Would not the pipe be so hard, with its thin walls, that it would be too brittle for practical use? And would not it be too hard for tapping or cutting with reasonable satisfaction? These questions may have opposed Mr. de Lavaud in his first line of defense, so to speak, but were speedily overcome, as later results show he went victoriously over the top. The de Lavaud machine-made pipe is taken from the machine to an annealing furnace, is there relieved of its excessive chill and when the process is completed it is properly tempered and in superb condition for machining, tapping or the handling to which it may be subjected. The centrifugal process is responsible for a pipe which, compared with the sand cast, is made with a higher degree of precision, greater strength, a denser metal, a smoother surface and greater uniformity. But I am obliged to admit that the order for the first car of de Lavaud pipe for the Macon Water Works was placed with more or less trepidation. As soon as the car arrived I personally inspected it with our Superintendent before unloading. Its appearance dispelled all doubts and after the first line was laid and the first tap made we bade farewell to the sand cast product that had served us so many years.

We now buy de Lavaud exclusively, having used sizes ranging from 6 to 16 inches. We are now considering a line of 20-inch about 10,000 feet in length. Should this become a reality de Lavaud will be used. We find this pipe to tap readily and can be easily cut. We use pipe cutters for all sizes, but before acquiring a full set a cold chisel was successfully employed. In using a chisel the best results can be obtained by tapping lightly with the hammer. We use Class 150, about the equivalent in classification of Class B, sand cast. After a general inspection at the foundry this class is subjected to a water test of 300 pounds. Even in our high pressure lines we rarely reach 150 pounds, however. I happen to know of a city in my state where the elevation is such that de Lavaud Class 150 pipe is subjected to a constant pressure of 185 pounds. When de Lavaud was placed on the market it was but natural that various tests should be made for comparison with sand cast. In all the strength tests that I have noted—tensile or otherwise—the ratio is approximately two to one in favor of de Lavaud. In my own estimation de Lavaud centrifugally made pipe is as far superior in strength to sand cast pipe as malleable iron castings are to the or-

dinary gray iron castings. Prof. Peter Gillespie, of the University of Toronto, cites a test showing the tensile strength of machine-made pipe to be 37,000 pounds to the square inch, and that of sand cast to be 16,000 pounds. One reason for this disparity is that in the sand cast product the large flakes of graphite in the iron weaken the structure. While the graphitic content is not eliminated from the iron in the machine-made product, the process of manufacture tends to disperse or scatter the flakes to the extent that they do not weaken the structure. Furthermore, in any sand made casting, the blow hole hazard must be reckoned with. The machine-made casting is free from this menace. Rust and corrosion are the enemies of all ferrous metals, but rough, coarse castings are more susceptible to attack than those with smooth surface. On this theory I would say that while machine-made pipe is not immune, it is perhaps more so than the rough, rugged, and irregular surfaces of the sand cast. We sometimes read of cast iron pipe that has been used in European countries for hundreds of years, which prompts the thought that its life may be measured by centuries. But the proven superiority of machine-made pipe suggests the thought in my mind that its life may well be measured by eternity. The limitations of time prevent a more exhaustive discussion of this subject. However, in conclusion permit me in a general summing up to make the following observations in connection with de Lavaud pipe:

It has the endorsement of the National Board of Fire Underwriters; its strength, as shown by practical tests, is approximately twice that of sand cast pipe; it is made with the utmost precision, free from warps and irregularities, the scientific process of manufacture ridding the metal of practically all its impurities; the smooth surface reduces friction to a minimum. Added to the above is the economy with which this pipe may be used. Manufacturing costs are less, as less equipment is required. This saving is not all added to the manufacturer's profit, but is shared with the purchaser or user. The lighter weight of the finished product, as compared with the sand cast means a saving in freight—also passed to the user. In its last analysis—a better product for less money. Every municipality that has not used de Lavaud pipe owes it to itself and its taxpayers to give it an impartial trial.

MEMPHIS, TENNESSEE

By James Sheahan[5]

Prior to 1922, the growth of Memphis was of the normal consistent kind as might be expected of any city having a progressive population and offering similar advantages. In 1922, however, the growth rapidly increased, taking on the proportions of a moderate boom.

In the subsequent development of suburban property and building up of the old part of the city, the demand upon the water department for extension of water mains to meet these new conditions grew in such proportions that in September, 1922, we were about 20 miles behind our extension schedule.

We did not have, of course, a sufficient amount of pipe in stock or under order to meet our requirements, and, upon investigation, the pipe market was found to be so crowded that it was impossible to secure delivery under six months. By much persuasion, we did succeed in getting a shipment delivered about the middle of December, but this lasted only a short time and the market then was in no better condition, so far as delivery was concerned, than in September.

At this time, the water department was in the midst of a program contemplating the building of a new pumping station and laying a number of large distribution mains, the entire cost being estimated at about $3,500,000. The situation was what might be termed desperate.

In March, 1923, the writer went to Birmingham to see what arrangements could be made for securing pipe for the work we had outlined. We found the Bessemer and Ensley plants running full capacity in the manufacture of cast iron pipe. They were, however, unable to fill orders on file and at the same time accumulate a stock for immediate delivery.

It was then suggested that we visit the plant in Birmingham in which a new water pipe was being manufactured by the de Lavaud process. During the very interesting trip throughout this plant, we saw numerous small machines on carriages that operated something after the manner of a carriage in a saw mill. The machine was carried forward revolving at the rate of about 1200 revolutions per minute. As the revolving carriage moved forward the molten

[5] Superintendent, Water Bureau, Memphis, Tenn.

iron was poured in through a long spout, the speed of the machine regulating the thickness and density of the pipe wall. After the completion of the pouring, the casting was taken from the mould, put on a carriage, weighed and passed through the annealing furnace. It was then rolled on a carriage to the testing machines. We saw numerous lengths of this pipe tested out at 750 pounds pressure, at which point each length was struck with a large hammer to determine whether or not it would stand the test. While there we saw a large end casting broken on one of the testing machines. This end casting is used to clamp the pipe while under test. The casting is about 8 inches thick and 2½ feet wide. Upon being questioned, the operator said on one length of pipe the pressure was carried up to 4500 pounds, which broke the machine before bursting the pipe. I do not know the thickness of the pipe, but the operator said it was a standard length of 6-inch pipe.

Due to the fact that it was a comparatively new product and was not being used to any extent, we were advised that our requirements could be taken care of immediately, if we would order de Lavaud pipe. After what we had seen, and in view of the strong recommendation and guarantee given by the company manufacturing this pipe, we decided to give it a trial. An order was placed and shipments began immediately. Upon the arrival of the first shipment in our storage yard, some of the men employed by the Department for years who had been laying nothing but sand cast pipe were very skeptical as to the strength and durability of the de Lavaud pipe. In unloading and handling some of the first shipments a considerable amount of breakage occurred due to a greater brittleness in this pipe than in sand cast pipe and to our inexperience in handling it. In cutting, also, we experienced some difficulty at first due to the same cause. Soon, however, as the men became familiar with the handling of it, these slight difficulties were overcome and we were handling it with no more breakage than would have been the case in sand cast pipe. Confidence in the de Lavaud pipe grew rapidly, and now the men like to handle it better than the sand cast pipe.

All the pipe we now buy of 12 inches or less is of de Lavaud manufacture, and we have laid between 50 and 60 miles of this pipe in the last four years, ranging in size from 6- to 12-inch. Of this amount, we have laid about 40 miles of 6-inch pipe.

In our opinion, there are many reasons for using de Lavaud pipe in preference to sand cast. Of these the following may be men-

tioned: It is lighter to handle, has no sand holes, blow holes or bad spots, is smoother inside, insuring less friction, and, finally, the cost per lineal foot is less than the cost of sand cast pipe.

The Bureau of Standards of Washington several years ago sent a representative to Memphis and requested that the water department coöperate in the burying of short lengths of various kinds of pipe for a test to determine what action the soil might have upon it. We buried de Lavaud, sand cast, galvanized and brass. Only a few months ago this pipe was uncovered in the presence of an inspector from the Bureau of Standards, and the de Lavaud pipe was found to be in the same condition as when buried. The other pipe showed varying degrees of disintegration.

De Lavaud pipe has satisfactorily proven its worth to us and we now have the utmost confidence in its efficiency and durability. The Memphis water department never recommends the use of any particular pipe or mechanical device. We are always glad to give our experience in pumping water, laying mains or in any other branch of our system to any one requesting the same, leaving to their judgment the matter of selection.

NEW BEDFORD, MASSACHUSETTS

By Stephen H. Taylor[6]

In 1922, it was my privilege to visit the foundry of the United States Cast Iron Pipe and Foundry Company, and see the de Lavaud process of making cast iron pipe, also to witness several tests of pipe made by that method and by the old sand moulding method.

This made such a favorable impression of the de Lavaud method that several lengths were ordered by the City of New Bedford for experimental purposes. We gave it a pretty thorough test as to cutting, threading, breaking, etc., and became thoroughly convinced that the new pipe was better than that made by the old method.

The de Lavaud pipe is considerably thinner, but the metal is so much more dense and the wall of the pipe so uniform in thickness that it stands a much higher test in all respects than the sand cast pipe designed for the same pressures. Since 1923 we have purchased and used de Lavaud, Class 150, pipe exclusively in the sizes from 4- to 12-inch inclusive. Our pressures run as high as 95 pounds

[6] Superintendent, Water Works, New Bedford, Mass.

We have not bought or used any 16- or 20-inch, since it was made by the de Lavaud method.

Our experience is that it is of much more uniform thickness than sand cast, is much smoother and, as it is made to fit the old bells, the pipe being thinner, makes the inside diameter about $\frac{1}{4}$ inch larger. The walls are amply thick to hold a sufficient number of threads on the corporation cock.

We find less breakage in handling from the cars at the foundry to the trench. We now have about ten miles of it in use and have had but one case of breakage under water pressure. This was under a pressure of about 90 pounds and was probably caused by an air pocket and water hammer, which would have been fully as disastrous to sand cast pipe.

We have never experienced any trouble from brittleness. Proper annealing when the pipe is being made eliminates this feature.

De Lavaud pipe has no bead on the spigot end, but we have never experienced any difficulty on this account and do not think the bead is necessary. We all place a great many cut pipes in our lines which have no beads and think nothing of it.

De Lavaud pipe has a centering ring in the bell which insures getting the pipe properly lined up on the inside when laying. This we find to be an advantage. Because of the slightly larger inside diameter and smooth bore the friction losses are less then in sand cast pipe.

We are using Class 150 de Lavaud which is only about three-fourths as heavy as sand cast pipe designed for similar pressures. This results in a saving in freight, hauling and handling, as well as in the cost of the pipe.

We usually receive bids for both sand cast and de Lavaud pipe when purchasing and find that the prices per foot, f.o.b. New Bedford, runs about 10 per cent less for de Lavaud. To this saving should be added the difference in cost of hauling and handling from the cars to our yard and to the job.

From our three years experience with de Lavaud pipe we are satisfied that it is the best pipe and that its use results in a worth while saving of cost.

BOILER FEED WATER STUDIES COMMITTEE

The Boiler Feed Water Studies Committee has been formed for the purpose of studying the various processes in the purification of feed water employed in steam stations and on railroads. Research work is being carried on to determine the fundamental principles of certain phenomena which take place in steam boilers. The results of the findings of the various committees are to be published from time to time in the Journals of the associated engineering organizations affiliated in this work.

The Committee has not given approval to any systems of feed water treatment and has not approved any product manufactured for internal treatment of boiler waters. Advertisements indicating this are untrue and misleading.

The Boiler Feed Water Committee is sponsored by the following organizations:

The American Society of Mechanical Engineers
The American Water Works Association
The American Railways Engineers Association
The National Electric Light Association
The American Society of Testing Materials

S. T. POWELL, *Chairman,*
Executive and Editing Committee.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Determination of Nitrates in Water by Frerich's Method. A. MASSINK. Chem. Weekblad, 21: 421-422, 1924; Chem. and Ind., 43: B 886, October 31, 1924. In presence of alkali bicarbonates, results obtained by Frerich's method (J. 1903, 1209) are too high. Experiments in which a solution of pure sodium sulphate in distilled water was evaporated to dryness after addition of hydrochloric acid, the residue being again moistened, showed that the residue remained acid and contained chloride. S. I. L.—*A. M. Buswell.*

Control Apparatus for Detecting the Slightest Trace of Free Chlorine in Chlorinated Water. W. OLSZEWSKI AND O. SPERLING. G. P. 396,043, 11.2.23. Chem. and Ind., 43: B 845, October 17, 1924. Apparatus consists of twin cylinders in which the color of the treated water is compared with that of a further portion of same water to which an indicator has been added. Latter consists of a solution of benzidine with traces of *o*-tolidine in hydrochloric acid in sufficient quantity to neutralize any alkalinity in the water. As little as 0.02 mg. of free chlorine per litre of water, gives a distinct blue-green coloration. (Cf. B., 1924, 728). C. I.—*A. M. Buswell.*

Water Analysis. J. ZINK and F. HOLLANDT. Z. angew. Chem., 37: 672–675, 1924; Chem. and Ind., 43: B 844, October 17, 1924. A method is described for determining hardness by titration with a modified Blacher's solution in which commercial palmitic acid is used instead of pure palmitic acid, denatured alcohol instead of pure alcohol, and glycerol is absent. The results obtained are satisfactory. River water often undergoes rapid change in composition when kept in warm weather, due to the removal of carbon dioxide by algae; the reaction towards phenolphthalein may change from acid to alkaline (e.g., river Weser). The determination of magnesium chloride by evaporating the water to dryness and extracting with alcohol does not give the actual quantity of this salt present in the original water owing to changes which occur during the successive separation of the various salts on evaporation. It is preferable to calculate the magnesium chloride content from a knowledge of the content of Ca, Mg, CO_3, SO_4, and Cl ions. W. T. K. B.—*A. M. Buswell.*

A Note on the Determination of the Permanent Hardness of Water by Pfeifer and Wartha's Method. ARTHUR LUMSDEN-BEDINGFELD. Chem. and Ind.,

45: 36T, January 29, 1926. In the course of routine control tests on a water-softening plant for the determination of the permanent hardness, the modification of Pfeifer and Wartha (Z. Anal. Chem., 1902, **41**: 198) of the usual Hehner method, for waters containing magnesium salts in addition to calcium, as suggested by Sutton ("Volumetric Analysis," 1924, p. 460), was investigated. It was found that by this method abnormal results were obtained, inasmuch that they were considerably in excess of that found in the untreated water by the usual sodium carbonate method and from the calculated permanent hardness from the analysis of the dissolved solids. In Pfeifer and Wartha's method, standard sodium hydroxide is used in conjunction with standard sodium carbonate solution, the water being concentrated, after the addition of these two salts, to about one-half its volume, the precipitated calcium and magnesium carbonates filtered off, and an aliquot part of the filtrate titrated. The presence of the sodium hydroxide in contact with the cellulose of the filter paper was suspected as the cause of the error and experiments were conducted to ascertain the truth of this. It is therefore to be seen that though this absorption is in itself comparatively small, yet when it is multiplied so as to express the results in terms of parts of permanent hardness per 100,000, the error introduced is considerable. Determinations therefore, by this method employing cellulose as the filtering medium hold no advantage over Hehner's method and are in fact distinctly erroneous.—*A. M. Buswell.*

Boiler Corrosion, Pitting, and Grooving. T. W. Lowe. Rwy. Rev., **78**: 23, 1041, 1926. Many years' observation of pitting and grooving in locomotive boilers operating on the Western lines of the Can. Pac. Ry. indicates that the corrosion is affected more by type and design of boiler than by action of the waters which analysis reports show to be largely of heavy scaling characteristics with possible contributory cause of high Mg ratio. Recommendations are made for chemical regulation of washout periods; top application of feed water with pan for collecting impurities; tension stays to combustion chambers; external by-pass circulating pipes; and systematic blow downs to relieve concentration.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

A Study into Causes of Pitting and Corrosion in Locomotive Boilers. W. M. Barr. Ry. Rev., **78**: 23, 977, 1926. An extended discussion with photographs on various phases of locomotive boiler corrosion. Recommendations for alleviation are: (1) boiler materials of uniform and constant composition; (2) avoid permanent strains in crystalline structure; (3) carry excess NaOH in water treatment; (4) maintain low concentration of distilled salts in boiler water by systematic blow off; (5) oxygen removal is beneficial; and (6) insure constant satisfactory water treatment regulation by competent supervision by responsible officer.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

The Past, Present, and Future of Water Treatment. S. C. Johnson. Ry. Age, **80**: 31, 1667, 1926. Review of the developments in Railway water softening with conclusion that competent supervision is the largest factor in procuring results.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

A Statement of the Problems now Confronting the Water Service Engineer. R. E. Coughlan. Ry. Age, 80: 31, 1669, 1926. Water treatment was started in an experimental way with 16 plants on the C. and N. W. R. R. in 1903. The 47 lime and soda softeners now in operation, supplemented by some partial and internal treatment, have largely eliminated scale and leaky conditions. Effort is being made to counteract corrosion by excess caustic treatment.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

A Forecast of the Probable Future Development of Railway Water Treatment. C. R. Knowles. Ry. Age, 80: 31, 1670, 1926. Possible refinements in filtration, design of settling tanks of sludge removal, combination lime-zeolite treatment, and internal treatment are given consideration.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Slaked Lime and Unslaked Lime. R. C. Bardwell and O. T. Rees. Ry. Engineering and Maintenance, 22: 2, 71, 1926. Advantages in use of hydrated lime for railroad water softening are: (1) convenience in handling; (2) slaking equipment expense avoided; (3) less expensive storage facilities; (4) more uniform strength; (5) less objectionable impurities. Advantage in use of unslaked lime is in lower first cost of material, only.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

How Hydraulic Rams Cut the Cost of Water. L. H. Robinson. Ry. Engrg. & Maint., 22: 2, 54, 1926. Replacement of 11 gasoline driven pumping stations on Bridgewater Division of Canadian National Ry. at cost of $35,470 has effected annual saving of $17,448.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Pitting and Corrosion. Anon. Ry. Rev., 78: 1, 506, 1926. Abstract of A. R. E. A. Water Committee report on status of pitting investigation.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Softening Locomotive Feedwater. Anon. Ry. Rev., 78: 11, 524, 1926. Abstract of report from A. R. E. A. water committee concluding that estimate of 13 cents per pound for scale kept out of locomotive boilers is below the actual saving.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Increased Facilities Serve Double Track. F. P. Turner. Ry. Rev., 78: 12, 557, 1926. In course of double tracking Norfolk and Western Railway between Naugatuck and Kenova, W. Va., new modern pumping station and water softening plant were included in Prichard, W. Va., terminal facilities. Duplicate electrical centrifugal pumping units located in 15 feet in diameter by 45 feet deep concrete well, deliver raw water from Big Sandy River to 60,000-gallon per hour continuous softener of tipping bucket control type. After five hours sedimentation, excelsior filter in top of softening tank aids in clarification. Revolving sludge remover driven by worm gear is used. A 200,000-gallon elevated steel tank provides treated water storage. Discussion of construction problems is accompanied with plans and photograph.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Pumping Water by Electric Power. Anon. Ry. Rev., **78:** 13, 603, 1926. Advantages in electric pumping stations on railroads are lower initial cost of equipment and reduction in attendance charge where automatic control can be incorporated. Lack of familiarity of water supply forces with electrical equipment and high power costs are a handicap.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Inspecting and Testing Materials. Robert Job. Ry. Rev., **78:** 13, 605, 1926. General discussion of the necessity, requirements, and benefits of railway testing laboratory.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Graver Develops New Design of Water Softener. Anon. Ry. Eng. and Maint., **22:** 4, 162, 1926. Proportioning device in new type of continuous flow softener depends for regulation upon variations in pressure upon opposite sides of orifice plate in main discharge line which admits a proportionate amount of water to regulating vat to lower floating suction in chemical vat. Balance of chemical equipment and sedimentation tank is similar to old models. Detail drawing and cross section view are given.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Water Station Building Design. Anon. Ry. Eng. and Maint., **22:** 4, 152, 1926. General discussion of railway water station buildings with recommendation for more permanent type of construction.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

An Easy Method to Determine Friction Losses in Water Pipe. F. J. Walter. Ry. Eng. and Maint., **22:** 5, 181, 1926. Elements influencing friction loss in pipe lines are discussed and graphic charts are presented for loss in various size pipe lines, tees, and elbows.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Illinois Central Builds an Automatic Water Supply Station. Anon. Ry. Eng. and Maint., **22:** 6, 230, 1926. In connection with installation of Markham Yard Terminal facilities near Chicago, Illinois Central Railroad constructed 50,000-gallon per hour pumping and softening plant to handle and correct raw water from Calumet River. Pumping equipment is of centrifugal type, electrically operated. Softening plant is of continuous type, using orifice and weir proportioning to lower floating outlet in chemical vat. In addition to five hours sedimentation, two open type gravity sand filters aid in clarification of treated water before distribution through five miles of 14 inch main to six 100,000-gallon storage tanks in yard. Lime and soda are used for softening. Both raw and treated water pumps, as well as chemical equipment, are controlled automatically by level of water in storage tanks. General plan and photographs are shown.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Revision of the Manual. Com. Rep. Amer. Ry. Engr. Assoc. Bul., **27:** 281, 179, 1925. Complete list of definitions for water supply terms used in railway practice.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Report on Regulations of Federal and State Authorities Pertaining to Drinking Water Supplies and Sanitary Examination of Drinking Water Supplies. Com. Rep. Amer. Ry. Engr. Assoc. Bul., **27**: 281, 193, 1925. Discussion of the latest adopted Treasury Dept. Standards for Railroad Drinking Water.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Pitting and Corrosion of Boiler Tubes and Sheets. Com. Rep. Amer. Ry. Engr. Assoc. Bul., **27**: 281, 194, 1925. Comments made on effect of: (1) H-ion concentration; (2) CO_2; (3) O_2; (4) alloys and coatings; (5) suspended matter, including mud and scale; (6) counter-electrical method; (7) design and construction of boilers; (8) kind and care of material.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Cost of Impurities in Locomotive Feedwater and Value of Water Treatment. Com. Rep. Amer. Ry. Engr. Assoc. Bul., **27**: 281, 197, 1925. Statistics are given showing savings from $1,000 to $8,000 per locomotive per year from water treatment; with statement that estimated saving of 13 cents per pound for scale removed should be conservative.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Comparison of Different Methods of Water Treatment. Com. Rep. Amer. Ry. Engr. Assoc. Bul., **27**: 281, 203, 1925. Lime-soda method is considered standard. Soda ash method requires systematic blowing for satisfactory results, costs for which are tabulated. Colloidal influence of proprietary boiler compounds is being studied and test of zeolite treatment on West Coast is under observation.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

The Relative Merits of the Different Methods of Deep Well Pumping. Com. Rep. Amer. Ry. Engr. Assoc. Bul., **27**: 281, 211, 1925. Individual conditions will govern the recommendations for installation of deep-well reciprocating, centrifugal, or turbine pumps, or the air lift.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

The Design, Construction and Maintenance of Pipe Lines. Com. Rep. Amer. Ry. Engr. Assoc. Bul., **27**: 281, 221, 1925. Intake, suction, discharge, gravity, and service lines are considered together with diagram and photographs of typical installations. Bibliography and recommendations are included.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Flow of Water in Pipes. F. J. Walter. Com. Rep. Amer. Ry. Engr. Assoc. Bul., **27**: 281, 235, 1925. Tables and charts are presented to show the friction loss in c. i. pipe, tees, and elbows.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Design and Construction of Water Station Buildings. Com. Rep. Amer. Ry. Engr. Assoc. Bul., **27**: 281, 236, 1925. Consideration is given to design of housing for plants operated by steam, internal combustion engines, and electric motors, and of deep well stations, water treating plants, intake wells, and pumper's cottages.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Report of Boiler Washing Plants as Affecting Water Supply. Com. Rep. Amer. Ry. Engr. Assoc. Bul., **27**: 281, 240, 1925. Time of men and locomotives is saved by washing with water at temperature of 120 degrees Fahrenheit and filling clean water at 200°F. The washout saving in labor, fuel and engine time is estimated at $5.98 per locomotive, and at $4.03 for a water change. Recommendation is made for cooling devices so that blown off water may be used for cleaning purposes and for sludge collecting systems in storage tanks.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Spare Parts to be Stocked in Oil Engine Plants. A. B. Newell. Power, **63**: 19, 704, May 11, 1926. A number of spare parts to be stocked for large and small engines are listed and parts most likely to wear quickest are discussed.—*Aug. G. Nolte.*

Some Problems in the Use of Pulverized Coal. A. G. Christie. Power, **63**: 20, 748, May 18, 1926. Powdered coal has established an enviable record for high economy in operation and for satisfactory performance. Though much has been accomplished, problems naturally arise which demand attention of engineers in their solution. Some newer problems are discussed and analyzed in this article. Author presents suggestions for improving coal preparation and burning, and evidence that ash may aid combustion. He stresses importance of adequate instruments and need of simple means for checking loss of carbon in flue gas and advocates development of dust catchers.—*Aug. G. Nolte.*

Considerations in the Selection of Electric Motors. J. Elmer Housley. Power, **63**: 20, 755, May 18, 1926. Selection of motor and of kind of drive to be used are considered from the broad economic aspect rather than as regards individual application.—*Aug. G. Nolte.*

Analyzing the Power-Purchase Problem. A. C. Wood. Power, **63**: 20, 777, May 18, 1926. Principal factors affecting choice between purchasing and generating power for industrial plants, particularly those requiring steam for heating and process purposes, are summarized and discussed.—*Aug. G. Nolte.*

Restrictions to Flow in Hydraulic-Plant Conduits. Power, **63**: 21, 830, May 25, 1926. Discussion of effects of constriction of water conduits of hydraulic plants by vegetable and animal growths on surfaces of water passages is included in section of National Electric Light Association's Hydraulic-Power Committee's 1926 report. Such growths cause considerable restriction to flow, with resultant loss of head. Copper sulfate, chlorine, and excess hydrate alkalinity treatments have been tried; copper sulfate being most successful. Amount of chemical required for each different form has been carefully worked out and tabulated; it is influenced by temperature, organic matter, alkalinity, and turbidity, and ranges from 0.07 to 10.0 parts per million. Liberation of copper ions into water by electrolysis has been suggested; but no comparative cost data as between this procedure and copper sulfate application have been prepared. In conduits, copper sulfate may be introduced

in solution, or by continuous dry feed. In reservoirs, method of control usually employed is that of dragging burlap bags filled with copper sulfate through the water. In a comparatively short conduit, covering of conduit should have advantages over copper sulfate method of control, whereas in a very long conduit, the cost of covering may outweigh advantages. San Joaquin Light and Power Company has had carrying capacity of concrete ditches and steel flumes reduced to 80 per cent of normal by algæ growths. Reduction of flow seems rather to be due to increased coefficient of friction than to reduction of sectional area. In operation of some power conduits of Southern California Edison Company, carrying capacity has been reduced by aquatic larvae of certain insects, attached to walls. Means of cleaning walls vary, but in large conduits scraping is most effective plan. For smaller conduits, pipes are swept by means of oak brush tied up into rough ball and carried through pipe by flow of water. No effective means of prevention have yet been developed. Several kinds of paint have been tried, but results were not conclusive.—*Aug. G. Nolte.*

Reliability of Hydraulic Turbines. Power, 63: 21, 829, May 25, 1926. Article is an abstract of National Electric Light Association's Hydraulic Committee's report, presented at 49th Convention, Atlantic City, N. J., May 17 to 21, 1926. It deals with results of an investigation made of the time that 56 hydraulic turbines were out of service compared with the outage time for 87 steam turbines.—*Aug. G. Nolte.*

Selecting Equipment for Western Avenue Pumping Station. L. D. Gayton. Power, 63: 22, 840, June 1, 1926. Relates some of studies and comparisons made when selecting mechanical equipment for new 300 m.g.d. steam pumping station at Western Avenue and Fiftieth Street, Chicago. Main pumps will be of centrifugal type, driven through gears by compound steam turbines operating on steam at 300 pounds gage pressure and 200°F. superheat. Preliminary designs and estimates were made to study and compare following type of equipment: Steam-turbine-geared centrifugal pumps, vertical triple-expansion pumping engines, Diesel-engine-driven centrifugal pumps and electric-motor-driven centrifugal pumps. A table giving the summary of the results of this study is included. Studies were then made of different types of steam boilers, combustion equipment, piping, etc. Mechanical stokers, powdered coal, and oil-fired boilers were considered. With view to high boiler efficiency, evaporator plant for distilling all make-up water is to be supplied to boilers. Evaporators will have capacity to provide 7½ per cent make-up, if necessary.—*Aug. G. Nolte.*

Keeping Insulation in Good Condition on Electrical Machines. C. L. Keene. Power, 63: 22, 846, June 1, 1926. Relates briefly some troubles that may be caused by defective insulation and recommends thorough cleaning of machines at frequent intervals.—*Aug. G. Nolte.*

Comparative Performance of Air Preheaters. N. E. Funk. Power, 63: 22, 852, June 1, 1926. Presents comparative data on different types of air

preheaters used with boilers, some equipped with economizers and some without, but in every case of approximately same design. Preheaters used varied not only in type but also in area of heating surface. Curves are presented showing comparative performances of the units.—*Aug. G. Nolte.*

Vibration in Hydraulic Turbine Machinery. Power, 63: 22, 868, June 1, 1926. Abstract of National Electric Light Association's Hydraulic Power Committee's report presented in Atlantic City, N. J., May 17 to 21, 1926. Results of investigations made to determine cause of vibration in hydraulic turbines under various conditions. Remedies for some of troubles are suggested.—*Aug. G. Nolte.*

The Application of Pulverized Fuel to the Industrial Plant. W. Edward. Power, 61: 20, 784, May 19, 1925. Certain basic considerations concerning use of pulverized fuel are outlined and procedure for making an installation proposal is discussed.—*Aug. G. Nolte.*

Direct-Current Motors Fail to Start—General Considerations. B. A. Briggs. Power, 61: 21, 831, May 26, 1925.—*Aug. G. Nolte.*

Operation of Diesel Engines. R. Hildebrand. Power, 61: 21, 831, May 26, 1925. Proper care of piston eliminates trouble and waste.—*Aug. G. Nolte.*

Suggested Rules for the Care of Power Boilers. Power, 61: 21, 847, May 26, and 61: 23, 924, June 9, 1925. Proposed as addition to A. S. M. E. Boiler Construction Code. Rules compiled to assist operators of steam boiler plants in maintaining their plants in as safe condition as possible, the subject of economy receiving only incidental consideration. Rules are suggested only and it may be advisable to depart from them in certain cases. Reprinted from Mechanical Engineering for May, 1925.—*Aug. G. Nolte.*

Thermocouple Easily Made for Small Plant Temperature Measurement. Charles E. Colburn. Power, 61: 22, 873, June 2, 1925.—*Aug. G. Nolte.*

Three Pounds of Soda Ash Daily Saves Boiler Tubes in New Orleans Plant. P. F. Hoots. Power, 61: 23, 899, June 9, 1925. Treatment has checked serious tube losses in oil fired boilers. Practically all tube failures were confined to lower rows where apparently impinging of flames produced overheating of metal and burning out of tubes. At present time three pounds of soda ash are used daily to treat average evaporation of 10,000,000 pounds of water. Soda dosage is determined by weekly analyses of boiler waters; the relationship between carbonate and sulphate contents being the determining factor. Tube failures were attributed to a very hard thin scale composed mostly of calcium sulphate.—*Aug. G. Nolte.*

Operation of Diesel Engines. R. Hildebrand. Power, 61: 23, 906, June 9, 1925. Why cylinder heads break and the remedy.—*Aug. G. Nolte.*

Questions and Answers. Franklin Van Winkle. Power. Subjects as follows: **61**: 21, 843, May 26, 1925. Pinholes in Galvanized Iron Water Pipe; Standard Atmospheric Pressure; Force Required at Crank Handle to Windlass. **61**: 22, 882, June 2, 1925. Excessive Calking of Boiler Seams; Water Contained by H. R. T. Boiler; Equalizing Draft of Boilers; Breakage of Gage Glasses from Scratching; Filtering Muddy Feed Water. **61**: 23, 920, June 9, 1925. Greater Clearance of Slide-Valve Engines; Discharging Condensate Derived From Superheated Steam; Operating Corliss Engines Much Underloaded; Change of Lead with Fixed Eccentric; Relative Feed Water for Same Boiler Capacity at Higher Pressure; Effect of Positive Lap of Steam Valves of Double Eccentric Corliss Engine; Foaming of New Boiler; Heating of Armature Bands; Back Pitch of Riveted Joints.—*Aug. G. Nolte.*

NEW BOOKS

Die Wasserbaulaboratorien Europas; Entwicklung Aufgaben Ziele. Unter mitarbeit von (among others) Conrad Matschoss, H. Engel, R. Winkel, Th. Rehbock, J. R. Freeman; Im Auftrage Des Vereines Deutscher Ingenieure; Herausgegeben von G. De Thierry und C. Matschoss. Berlin: G. M. B. H. Cloth; 8 × 12 in.; pp. 431; 50 reich marks in Germany. Experimental hydraulic laboratories have long been accepted by American engineers as useful supplements to experience gained in practice. Although controversy may still arise as to the adaptation of the results of such small scale experiments to practical performance, without careful adjustment, there is little doubt that the work performed in such laboratories and the results obtained have produced excellent returns on investments. The continental European countries have contributed a great deal to this feeling indicated above by their excellent contributions for many years to literature and to practical solution of hydraulic problems. It is with a great deal of interest, therefore, that the Volume under review has been received in this country. The book is unique in a number of ways, because it summarizes in considerable detail and in interesting style, the performance of a number of hydraulic laboratories in Germany, Sweden, Austria, Czecho-Slovakia and Russia; it elaborates upon the very close relationship between experimental studies in these laboratories and practical accomplishments; it describes in detail the form and equipment of the laboratories for hydraulic experimentation and it summarizes with remarkable clarity and brevity the results of such experimentations.

The list of topics discussed in this fashion gives of itself an excellent idea of the variety and practical importance of the problems considered. These include improvements of the bed of rivers with shifting bottoms; flow effect on sandy bottoms as influenced by groins; protection of pier foundations; imitation of flows in miniature of certain rivers; studies of proper locations of harbors; studies on spillway or relief weirs; effect of storm waves on protection walls.

Of particular interest to American engineers is the fact that this unusual volume is largely due to the stimulation of John R. Freeman, one of America's outstanding hydraulic engineers. He likewise contributed the first chapter to the volume, which, in itself, is worth the price of the book. The contribu-

tions by the professors in charge of the laboratories discussed herein are unusual and valuable additions to the literature of hydraulics. They have conferred a real favor upon the profession by making the data, the description, the problems and the importance of hydraulic laboratories available to co-workers. The book contains a carefully prepared table of contents, an alphabetical index, many valuable bibliographies at the end of chapters and a number of illustrations and cuts of excellent style and character. The general arrangement of the entire volume attest the excellence of the publisher's art. A translation of the entire volume into English would be a most welcome addition to the scientific and practical literature of this country.—*Abel Wolman.*

Applied Municipal Sanitation. Published by Texas Association of Sanitarians, 1925. 167 pages. This volume, covering all branches of municipal sanitation, contains a number of helpful cuts, photographs and posters. The subjects are briefly outlined as follows:

Water. The subject of water is covered thoroughly. Beginning with the protection of sources of supply, it is followed through the various steps of aeration, sedimentation, coagulation, filtration and disinfection. A portion of the U. S. Public Health Service Standard for drinking water, the standard regulations of Texas governing the quality of drinking water, a score system of grading water supplies according to sanitary conditions, regulations regarding the preparation and submission of plans for improvements and new waterworks systems and purification works, and a suggested laboratory equipment, are given.

Sewage Disposal. The disposal of sewage by dilution was employed in Texas until society frowned upon this method. Today it is only permitted in tidal waters, and even here the oyster industry is voicing its objections. Most Texas plants provide grit chambers and some provide coarse screens, bar type, with $\frac{3}{4}$-inch to 1-inch clearance. Sedimentation basins are usually designed for retention periods of one to eight hours. It has been found that the bulk of suspended solids will usually settle out after the first two or three hours. Only a small minority of the Imhoff installations have occasioned odor complaints. At Austin the Imhoff tanks are covered and the gases are collected by a suction fan and burned. As in the case of water chlorination, it is becoming more and more apparent that sufficient chlorine must be applied to obtain a distinct residual free chlorine test in the treated effluent before effective disinfection is accomplished.

A law protects Texas streams from pollution by prohibiting the discharge of sewage, industrial wastes, and trade wastes into any stream without treatment. A strict interpretation requires the treatment to be such as will effectively remove polluting matter, injurious compounds, and pathogenic bacteria from the waste to a degree where it would not impair the quality of water in the stream into which the waste is discharged.

Definitions of sewage terms, regulations on the preparation and submission of plans for sewer improvements and treatment plants, a suggested plumbing ordinance, and a suggested privy ordinance are included in this chapter.

Mosquito Control. The beginning of active field mosquito control work in Texas dates back only about five or six years. Since that time by a gradual

process of education and demonstration, interest has been extended and funds provided for systematic control measures which are now kept in operation practically the year around in approximately eighty cities and towns in the state. The records show that malaria alone has been reduced 28 per cent for the past fiscal year, 1924, which is largely attributed to this active field work. The life history of the mosquito, methods of control and a proposed mosquito control ordinance are given.

Milk Sanitation. Milk and milk products are being shipped into Texas from other dairying states, despite the fact that it is more favorably situated for the production of milk. The adoption of the U. S. Public Health Service standard for grading milk by municipalities is recommended.

Shellfish Protection. A short chapter on the status of the work in Texas.

Camps—Parks—Swimming Pools. Requirements for camps, and standards for swimming pool construction and maintenance.

Problems of General Sanitation. This chapter treats of housing, slaughter-houses or abattoirs, food protection, fly control, rodent control, garbage and refuse, sanitary surveys and industrial and other wastes.

Educational Work. Keeping in mind that the individual must be reached, the State Health Department endeavors to bring the practical problems of sanitation to the attention of a majority of the people of Texas through a great number of avenues.—*A. W. Blohm.*